JOURNAL

OF

ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

VOL. 14 JUNE, 1921 No. 3

Proceedings of the Thirty-Third Annual Meeting of the American Association of Economic Entomologists

(*Continued*)

Afternoon Session, Friday, December 31, 1.35 p. m.

PRESIDENT WILMON NEWELL: The first paper is by C. H. Hadley.

THE STATUS OF THE WORK AGAINST THE JAPANESE BEETLE[1]

By C. H. HADLEY, *Riverton, N. J.*

A year ago, a paper[2] was presented at the meeting of this association, which gave a history of the Japanese beetle[3] in this country from the time of its discovery up to that time, as well as a general statement of the several phases of the problem. During the past season, the plan presented at that time has been followed rather closely.

In the paper now presented, it is intended to discuss the present status of the work against the Japanese beetle, with particular reference to the lines of work to be followed.

ORGANIZATION

The project is financed by the Bureau of Entomology of the United States Department of Agriculture, in cooperation with the Departments of Agriculture of the States of New Jersey and Pennsylvania. Dr.

[1]Published by permission of the Secretary of Agriculture, U. S. D. A., and N. D. A.

[2]Davis, J. J., JOUR. OF ECON. ENT., Vol. 13, (1920) No. 2, pp. 185–194.

[3]*Popillia japonica* Newm.

A. L. Quaintance, Dr. J. T. Headlee, and Prof. J. G. Sanders, respectively representing the cooperating agencies, form an advisory committee for the project as a whole, the administration of which has been assigned to the writer. Permanent headquarters in the form of an office, laboratory and storehouse are maintained at Riverton, N. J., in the heart of the infested territory.

The work has recently been reorganized along certain definite lines, as follows: Quarantine enforcement, insecticidal investigations, parasite investigations, bionomical investigations and control operations.

Quarantine Enforcement

There now exist three quarantine orders against the Japanese beetle, quarantine No. 48 of the Federal Horticultural Board, restricting interstate movement of products, and quarantines imposed by the states of New Jersey and Pennsylvania, restricting intra-state movement of products within those states respectively. The necessary authority for nforcing the local quarantines has been delegated to the Federal authorities. The quarantine enforcement work is in charge of Mr. C. W. Stockwell, and since a paper on this subject will be presented during the session, it is not necessary to discuss it further now.

Insecticidal Investigations

The investigations having to do with development of insecticides for this insect are being carried on by Mr. B. R. Leach and his associates. These investigations are being developed along the following lines:

(1) *To perfect an arsenical insecticide which will be a satisfactory killing agent.* As stated in the paper referred to previously,[1] the standard arsenicals ordinarily used against leaf-eating insects act as repellants rather than as killing agents in the case of the Japanese beetle. Substantial progress has been made in the development of an arsenical suitable for the purpose, and further extensive work has been planned along this line. For this purpose, a fairly complete field chemical laboratory has been equipped.

(2) *To devise methods of treating balled earth infested with Japanese beetle grubs.* The quarantine regulations prohibit the shipment of nursery stock requiring soil around the roots during shipment, except where such stock and soil is known to be free of infestation. Such

[1]Davis, J. J., 1920.

plants as evergreens and azaleas, can only be shipped in this manner. It is obviously impractical to examine such shipments for soil-inhabiting insects with any degree of accuracy, without first removing the soil, a practice which would be injurious if not fatal to the plant. An extensive series of dipping tests is in progress to develop if possible a method of treating such plants for grubs without injury to the plants.

In dealing with large shippers of the kind of stock just mentioned, any dipping method of treatment would involve so much labor and loss of time as to make such methods impractical on a large scale. An investigation has been commenced to determine the effect of vacuum and pressure on grubs and plants with soil about the roots. A large experimental outfit has been acquired, capable of an experimental range up to 28 inches of vacuum and 200 lbs. pressure. In general, tests will be planned to determine the mechanical effects of vacuum and pressure on the grub, the effect of toxic solutions on the grub in the soil under vacuum and pressure, and the effect of insoluble gases on the grub in the soil under vacuum and pressure.

(3) *Investigations to find materials suitable for killing grubs in the field.* The field cyaniding work carried on as part of the control work during the past two seasons has been expensive, and this method is hardly practical for the owner of infested territory to adopt. A series of experiments are now in operation, to endeavor to find a material less expensive than sodium cyanide suitable for this purpose, and to devise a more satisfactory method of applying such materials in the field.

Parasite Investigations

Mr. C. P. Clausen is in charge of the parasite investigations in Japan, and although he has been there less than a year, has made substantial progress. At Riverton, a comprehensive investigation of the parasite situation in the infested districts of New Jersey and Pennsylvania is now being inaugurated. A detailed study will be made of possible native parasites or predators attacking the Japansee beetle in any of its stages, and arrangements have been made to bring to Riverton from other parts of this country certain parasites known to attack white grubs of the same relative size as the grub of *Popillia japonica*.

In view of the heavy mortality incident to the shipment of living insects from a country as distant as Japan, it seems far more practical to attempt large scale rearing for colonizing here at the laboratory, rather than to depend entirely on material coming from Japan for colonizing purposes. Mr. Clausen is now in a position to ship material

in fairly large quantities this coming season from Japan, and extensive rearing work will be undertaken at Riverton with this material.

Bionomical Investigations

A preliminary life history study of the insect has already been made and reported on,[1] but experience has already indicated the need of a more exhaustive bionomical investigation of the insect. It is natural to suppose that an insect such as the Japanese beetle may accommodate its habits more or less to its environment, and that as it spreads, the rate and direction of the spread will be influenced by environmental conditions. Consequently a more detailed investigation of the bionomics of *P. japonica* has been commenced, taking up its life history, seasonal history, habits of flight, feeding, and reproduction, present and probable future status as a pest of our principal crops, factors influencing or limiting its geographical or climatic range, etc.

Investigations are also being conducted to determine the effectiveness of cultural methods against the insect. Farm practices now in vogue in this vicinity have failed to reduce infestation to any appreciable extent, and cultural practices commonly recommended have so far apparently had little influence on the relative abundance of the insect.

Control Operations

During the past season a strenuous effort was made to maintain a "barrier band", as described in the paper mentioned earlier.[1] Without giving a detailed discussion of the summer's work with the barrier band, it is enough to say that while in no case did the beetle succeed in actually working through the band by its own efforts alone, it has spread to such an extent, through artificial agencies, as to make further band work impractical, within a reasonable cost. Therefore this phase of the control work will be dropped.

Roadside spraying with a repellent will be continued along the main roads running through the infested territory. Such cleanup work will be continued as may be necessary to remove heavy growth which would hinder the spraying work, and to keep the main roadsides as clean as possible, in order to minimize to the greatest possible extent the further spread of the insect during its season of flight, through the agency of passing vehicles, pedestrians, and otherwise.

---

[1]Davis, J. J., N. J. Department of Agriculture Circular, 30, 1920.

[2]Davis, J. J., 1920.

In the spraying work, a strong repellent will be used, with which the vegetation will be kept coated throughout the beetle season. For practical results, it is essential that the roadside vegetation along the main traveled roads throughout the infested territory be kept in a condition as little attractive to the beetle as possible, so as to offer the least favorable conditions for the insects to feed and congregate there.

In connection with the insecticidal investigations, large scale spraying experiments will be undertaken during the coming season, for the final testing of killing agents against the beetles, in anticipation of renewed control spraying another season, if the materials tested react favorably.

Summary

For the past two seasons, greatest emphasis has been placed on eradication or control of this insect. The work has now been reorganized more particularly along an experimental basis, looking forward to the time when active control work can again be undertaken on a comprehensive scale, with some assurance of reasonable success. In addition to the experimental work, parasite importation, breeding and dissemination will be pushed vigorously, to hasten the day when the parasites and predaceous enemies of the beetle may become an important factor in keeping the pest within reasonable bounds and comparable with other native pests. Meanwhile quarantines will be enforced as efficiently as possible, along with other restrictive measures, in an effort to delay and hinder the spread of the insect.

President Wilmon Newell: The next paper is

THE SPREADING OF SPRAYS

By William Moore, *St. Paul, Minn.*

(Withdrawn for publication elsewhere)

Mr. C. L. Metcalf: I would like to ask how to measure the surface tension which is so important in this sort of work.

Mr. William Moore: It is hardly worth while to measure the surface tension of the liquid, since the interfacial tension comes into play. I have not given any figures of the interfacial tension because it has not been possible to measure the interfacial tension of the leaf

and spray. For surface tension I use the drop-weight method, based upon the weight of a certain number of drops. A definite volume of a standard liquid of known surface tension is run through the apparatus and the number of drops determined. This number is compared with the number of drops of the unknown liquid when the surface of the unknown may be calculated by a simple formula. In the case of such substances as casein, etc., it is almost impossible to measure because of the low speed at which the molecules of the casein are adsorbed on the surface, so that you have to allow something like one-half hour to an hour for each drop before it breaks from the tip of the apparatus. What we are interested in is not the static surface tension but the dynamic surface tension which is the one at the moment of spraying. I think that there is no doubt that we produced a film on the leaf which rolls together into a drop. What we are interested in is maintaining the film already produced.

MR. R. L. WEBSTER: I would like to ask whether there is a difference in the surface tension of soft and hard soap, for instance, oleate and potassium?

MR. WILLIAM MOORE: I suspect that the oleate would have the lowest. I think there would be a difference between the oleate and the stearate. The oleate soap would probably have a lower surface tension than the stearate soap, although I cannot give you any figures.

PRESIDENT WILMON NEWELL: The next paper is

ECOLOGICAL OBSERVATIONS ON THE HEMIPTERA OF THE CRANBERRY LAKE REGION OF THE ADIRONDACKS

By HERBERT OSBORN, *Columbus, Ohio* and C. J. DRAKE, *Syracuse, N. Y.*

(Withdrawn for publication elsewhere)

PRESIDENT WILMON NEWELL: We will now hear the paper by Mr. Swezey.

SOME RECENT INSECT IMMIGRANTS IN THE HAWAIIAN ISLANDS

By O. H. SWEZEY, *Experimental Station, H. S. P. A. Honolulu, Hawaii*

It is the prevailing opinion that the endemic insect fauna of the Hawaiian Islands has developed from ancestral forms which arrived as chance immigrants from elsewhere. Many of these immigrants ar-

rived a long, long time ago. Immigration, however, is a process that has continued thru the intervening time, even to the present. Many species of insects have arrived and become established in modern times, and have not yet changed so as to become peculiar to the Hawaiian Islands, but have a wide distribution to other Pacific Islands or to the continental shores of the Pacific. Much of the insect fauna of the lowlands in Hawaii is made up of such widely distributed species.

Then more recently has been the immigration in connection with human enterprises, the coming of insects in various ways thru commerce, as chance wanderers on ships, or as insect pests infesting plants, fruits, or various other foods and articles of commerce. In the latter way, many cosmopolitan pests had become established in Hawaii long before there were any attempts made to prevent it by means of quarantine inspection or other means.

For about twenty years very efficient quarantine practices have been in effect at the port of Honolulu, and many kinds of insect pests are thus intercepted which might be of serious importance should they gain entrance and become established. This constant vigilance does not entirely check insect immigration, however, and we are annually finding more new arrivals, most of which are of no importance, some are beneficial, and an occasional one proves to be injurious.

Some of the insect immigrants that have been noted most recently (1919 and 1920) are here given with notes as to distribution, habits, importance, etc. Many of the smaller ones no doubt have been present for several years and escaped notice. Unless stated otherwise, they were first observed in Honolulu.

HYMENOPTERA

Megachile sp. [Apidae]

Specimens of this hitherto unknown bee were first captured at Mokapu, Oahu, September, 1920. None have been taken elsewhere as yet.

Vespa occidentalis Cresson. [Vespidae]

This American wasp was first recorded from a single female taken at Halemanu, Kauai, at an elevation of 3500 feet, by Mr. H. P. Agee, January 30, 1920. Later Mr. J. A. Kusche reported to have seen it abundant in the same region of Kauai in April, 1919. It has not been seen anywhere else in the Islands yet. It is very strange that this insect should become established first in the midst of mountain forests.

Silaon rohweri Bridwell. [Sphecidae]

This wasp was first reported in May, 1919, from the coast at Waianae on the west side of Oahu. In August, 1919, it was found at Ewa on the southwest part of Oahu, and in August 1920 was found in Honolulu. This tiny little wasp stores up nymphs of a bug (*Nysius* sp.). It is considered as an immigrant, possibly from Central America or Mexico.

Itoplectis immigrans Timberlake. [Ichneumonidae]

This Ichneumonid was first recorded in May, 1919, but from specimens collected at several previous dates, the first being 1906. It is known from Kipahulu, Maui, and widely distributed on Hawaii. It is not known from whence it came.

Cephalonomia sp. [Bethylidae]

A black species first collected in the Waikiki marshes, Honolulu, May, 1919, and in the Ewa coral plain June, 1919. Bred from Scolytid larvae. Source not known. It is possibly an undescribed species.

Anagyrus antoninae Timberlake. [Encyrtidae]

Reared from *Antonina indica* in Honolulu. First reported in July, 1919, however, it was presumably introduced with its host years ago from some part of the Orient.

Plagiomerus hospes Timberlake. [Encyrtidae]

Collected at Nuuanu Pali, Oahu, October, 1919.

Anabrolepis extranea Timberlake. [Encyrtidae]

Collected on Mt. Tantalus, Oahu, October, 1919.

Pachyneuron anthomyiae Howard. [Pteromalidae]

Bred from the fly *Leucopis nigricornis* in Honolulu. First recorded September, 1919.

Diptera

Allograpta obliqua (Say). [Syrphidae]

First recorded in February, 1920. Found feeding on *Aphis maidis* on corn in Manoa Valley, and at the U. S. Experiment Station. Collected at Leilehua near the middle of Oahu, May, 1920; and in Olokele Canyon, Kauai, September, 1920

Eristalis aeneus Sapoli. [Syrphidae]

First found in Honolulu, August, 1919; at Ewa, Oahu, September, 1919; at Waianae and Manoa Valley, Oahu, October, 1919. It became very abundant at windows in houses in just a few months after it was first noticed. Its breeding habits in Honolulu have not yet been discovered, but it is thought to breed in muck or filth of some kind.

Anthomyid fly. [Anthomyidae]

An undetermined Anthomyid was first reported in April, 1919, at Lunalilo St., Honolulu. In May, 1920, it was found rather common in Kaimuki, a suburb of Honolulu, four and a half miles out. Its habits are not definitely known.

Bibionid fly. [Bibionidae]

Reported May, 1919 at Waikiki, Honolulu.

Itonidid. [Itonididae]

First recorded in September, 1919 at Waipio, Oahu. Later found at Ewa and Wainae, Oahu. Its larvae were feeding on *Aphis sacchari* on sugar cane, often very abundant. Its name and source have not been determined.

Psychodid. [Psychodidae]

An unknown black species reported common at Waikiki, Honolulu, February, 1919.

Coleoptera

Bruchus limbatus Horn. [Bruchidae]

First recorded in July, 1919. Bred from seed of monkeypod tree at Waipio, Oahu. Since then it has been found generally distributed in Honolulu, and as far inland as Castner, about the middle of the Island. Besides the monkeypod, they have been found destroying the seeds of a few other related ornamental trees. This weevil occurs in the Southwestern States and Mexico.

Calandra taitensis Guerin. [Calandrinae]

The Tahiti coconut weevil was first found at Honaunau, Hawaii in August, 1919. During the same month and in September, it was found at other ports on the lee side of Hawaii, but could not be found on the windward side after considerable search. Apparently it has been present where found for a number of years, but has escaped notice. It is not harmful to the trees as the larvae feed only in the edges of the leaf stalks near the base, and the trees where they were the most numerous were flourishing better than one ordinarily sees. It has not yet been found on any of the other Islands.

Stennomatus musae Marshall. [Cossoninae]

This weevil was first found in a garden at Kaimuki, a suburb of Honolulu, February 19, 1920. Larvae, pupae and adults were numerous in a decaying banana stump or corm. They have not been found elsewhere as yet. It is a very small species of Cossonid, and has been named as a new species by Dr. Guy A. K. Marshall, the description to be published soon.

Trogoderma sp. [Dermestidae]

This Dermestid was first reported in Honolulu in October, 1920, from having been found breeding in large numbers in a box of packages of miscellaneous garden seeds that had remained undisturbed for some months. Specimens were later found in collections dated May and October, 1919. It is probably American, tho the species has not yet been determined.

Nitidulid beetle.

Recorded October, 1919, from Haleakala, Maui.

Clerid beetle.

Recorded November, 1919, from dead wood, Honolulu.

Homoptera

Aphis middletonii Thomas. [Aphididae]

First identified and recorded in December, 1919, on the roots of *Coreopsis* and China aster, but known to have occurred on asters as early as 1910.

Thoracaphis ,ici. [Aphididae]

First recorded June, 1920, but had been previously collected in March, 1918.

Coccus acutissimus Green. [Coccidae]

First recorded in March, 1920, on litchi, but has probably been present for a long time.

Orthoptera

Teratura sp. [Locustidae]

First collected at Hilo, Hawaii, July 25, 1919, at lights. It has been on the in. rease there since, but its habits have not been learned as they are found only when coming to lights, and females only.

NEUROPTERA

Chrysopa sp. [Hemerobiidae]

A species similar to the American *Chrysopa externa* Hagen. First recorded in November, 1919, but examination of collections shows its presence as early as 1914. It is known on Maui as well as Oahu. The larvae feed on various kinds of plant lice.

Single or few specimens have been taken of a number of other foreign insects under circumstances not conclusive of their being established. For example: *Apion* sp., *Scypophorus* sp., a Cerambycid, a Malachiid and a Bostrychid.

Twenty-six species are above enumerated, as per records in the Proceedings of the Hawaiian Entomological Society. These species are distributed in the Orders as follows: Hymenoptera 9; Diptera 6; Coleoptera 6; Homoptera 3; Orthoptera 1; Neuroptera 1.

MR. A. H. ROSENFELD: I would like to ask if burning of sugar cane trash is general in Hawaii, and if so, what effect it has on the parasites?

MR. O. H. SWEZEY: The burning of trash is general before sugar cane is harvested, and in almost the entire cane district fire is run through the fields to burn the trash and facilitate harvesting. We believe it has no effect upon the parasites of insects pests, for the reason that in all cases there are sugar cane fields growing in all stages from very small to mature cane, and the pests and parasites, if present, have migrated to these different fields and become established. Parasitism is well under way before a mature field is burned off in the process of harvesting.

MR. L. O. HOWARD: I was told that there was a case in the summer of 1915 when a leafhopper outbreak on the Island of Oahu was said to be due to burning of trash and the destruction of the parasites.

MR. O. H. SWEZEY: There has been injury in this way at times to isolated fields, but in general the damage to parasites by burning fields is as I previously stated.

PRESIDENT WILMON NEWELL: The next is by W. H. Larrimer.

GRASSHOPPER AND CRICKET REPELLENTS[1]

By WALTER H. LARRIMER, *Scientific Assistant, U. S. Bureau of Entomology, West LaFayette, Indiana*

[1]Published by permission of Secretary of Agriculture.

Much has been done to secure a bait with which to poison grasshoppers and crickets and as evidence of creditable results obtained, we have poison bran mash with various attractive agents enough to suit the conditions of most any locality as well as the fancy of any particular entomologist.

For several years there has been much trouble experienced by farmers in widely separated localities from grasshoppers and crickets cutting the bands of the sheaves while the grain is in the shock. In the case of grasshoppers this trouble could be prevented by poisoning the -nsects in question before the grain is cut but unless this procedure were practical for other reasons a more suitable remedy is to be desired. Since so much effort seems to have been necessary to secure a suitable attractive poison bait, it would naturally be expected that a suitable repellent could easily be found which might be applied to binder twine to prevent this damage. Since records on this subject are so rare and brief in Orthoptera literature, it seems desirable to include here all references which can be found.

Criddle. Report of Canadian Experimental Farms 1884-1904. Report of Entomologist, 1903. Page 174.

"Some damage was caused from locusts eating binder twine; very few had bluestoned the twine, and we have now been able to demonstrate without a doubt that some brands of binder twine are much more subject to attack than others. Whether it is that certain brands are made of different materials or that they are looser than others, I cannot say; but the twine which was most attacked is very loosely twisted."

Howard. U. S. D. A., Div. Ent. Bul. No. 30, page 94.

"Insect injury to binding twine:- We have received several complaints of injury by crickets and grasshoppers to binding or binder twine, which we are informed is used for stacking small grain in the field, a remedy or preventive being desired. During May 1901, Mr. I. D. Sheaffer, Russell, Kansas, and Miss Annette Bowman, Moscow, Idaho, wrote in regard to such injury. These are only two of several complaints. In no cases have we received specimens of the insects, nor have we been able to suggest any substance that would kill the insects or deter them from attacking the twine that would not at the same time be dangerous to those handling it. Poisons, of course, could not be used, and sticky substances would also be objectionable, although of course, they would prevent injury by the insects."

Gibson & Criddle. Canadian Department of Agriculture. Crop Protection Leaf let. No. 6. Page 3.

"Damage to Binder Twine In the Prairie Provinces considerable injury, some years, has been caused by locusts, as well as crickets, eating binder twine

when grain is standing in stocks. Some kinds of twine, as for instance thrt which is loosely twisted, has been more attractive to insects. We have used several mixtures to protect the twine from locust injury and the following has been found most useful.

Bluestone	1 pound
Water	6 gallons.

The balls of binder twine should be soaked in the solution for half an hour, and then dried thoroughly before using. The mixture, of course, is not intended to destroy locusts: it simply acts as a deterrant."

Washburn. Minn. Agric. Expt. Station. 1903. Press Bulletin No. 16, page 6.

"To prevent crickets and grasshoppers from eating binder twine in the fields: Soak balls of twine in a solution of 2 lbs. bluestone dissolved in 12 gallons of water, for half an hour and then dry it thoroughly. (H. Vane, in Canadian Report.)

It must be remembered that it is hard to dissolve bluestone; it should therefore be placed in the water quite a long time before the liquid is to be used.

A farmer here suggests soaking balls of twine in kerosene. This might be effective."

Being unable to locate the vague reference to Mr. H. Vane, the following explanation is offered through the courtesy of Mr. Criddle in a letter of recent date.

"The experiments conducted by Mr. H. Vane were undertaken with a view to protecting the binder twine from the ravages of locusts. Several substances were tested, including coal oil and salt, but the only one giving immunity was from soaking the balls of twine in a solution of Bluestone (Copper sulphate) and water.

I may say that the Bluestone solution was used by many of us and proved very satisfactory excepting for the fact that it had a tendency to weaken the twine. We found also, that it tended to clog in the binder but that it worked much better when thoroughly dried.

Mr. Vane is a farmer of these parts and has not published any information on the above subject."

During the past season, in order to obtain further information on this this subject, a series of experiments was conducted in which one to two hundred sheaves were bound in the usual manner, with each of the several variously treated twines and exposed naturally in the field. A similar test was run in each of six widely separated localities from which trouble of this sort had been reported the previous season. Just before threshing, an examination was made for cut bands and not a single band was found cut in any locality, even of the untreated twine used as a check.

It was then decided to carry out some elimination experiments by some other method to determine if possible which of the ordinary repellents would probably be best for actual field application. The method of determining the relative value of the various repellents used was the same as described by Larrimer and Ford in a previous paper

on "Observation on the Attractiveness of Materials used in Grasshopper Baits." Small amounts of wheat bran were treated with the various repellents, these samples were exposed under natural conditions in the field, and the crickets and grasshoppers observed within six inches of the bran or feeding upon it, were recorded. In all cases the various samples were run in duplicate and interchanged frequently so that any variation of results might not be due to advantage of location. A pair of field glasses was used to make the counts since, by this method, accurate counts could be made with the observer stationed twenty or thirty feet from the bran samples and thus not disturb the crickets or hoppers which were being counted.

In choosing the following materials as fairly representative of the various groups of the common repellents, the availability and cost was of course an important consideration. Soap, gasoline, sulphur, aloes, creosote oil, furniture polish, nitrobenzine, nicotine sulphate, auto oil, kerosene and copper sulphate were each mixed with small samples of wheat bran and these exposed in the center of card board discs twelve inches in diameter and cross marked with black lines to facilitate counts. These discs were placed in a tract of uncultivated land grown up to weeds, uniformly but not heavily, infested by grasshoppers and crickets.

Melanoplus femur-rubrum was by far the predominating species of the grasshoppers present but some *M. atlanis*, *M. differentialis*, *Dissosteira carolina*, *Encoptolophus sordidus*, *Scudderia furcata*, *Orchelimum vulgare*, and a species of *Conocephalus* were also taken.. The species of crickets taken in the counts were *Gryllus assimilis pennsylvanicus* and *Nemobius fasciatus*. Wet bran was used as a check and since black strap molasses has been found to be one of the best attractive agents, samples of bran treated with the standard strength of this material were included as an additional basis of comparison.

The bran samples were moistened with the various materials mixed in the following strengths. The liquid repellents, black leaf 40 excepted, one part repellent to four parts water; powdered aloes or sulphur, one tablespoonful to one pint water; copper sulphate, a saturated solution in water; black leaf 40, one tablespoonful to one pint of water; soap, either Ivory or fish oil, as strong a solution as possible in cold tap water. It was not practical to run all of the materials at one time, but four seres were run on the following inclusive dates Series 1, August 23 to 25; Series 2, August 31 to September 1; Series 3, September 21 to 22; Series 4, October 5 to 8.

In Series 1, fresh samples were used for August 23 and 24 and those

used on the 24th were left in position over night and used on the 25th. In series 2, 3, and 4, the original samples used on the first day of each series were left in position at night and run for the entire period. The total number of crickets and grasshoppers for each material and each series is indicated in Table 1.

Table I.

	Crickets				Grasshoppers			
Series	1	2	3	4	1	2	3	4
Soap		743	64	225		364	829	881
Black Strap	1667	286	12	118	593	243	232	503
Water	922	203	10	137	609	214	348	392
Gasoline	948				499			
Sulphur				145				347
Aloes		370	13			161	191	
Creosote Oil	1031				390			
Furniture Polish	780				427			
Nitrobenzine			6				133	
Nicotine Sulphate		175		66		155		161
Auto oil	573				347			
Kerosene	345	146	6	31	372	193	72	160
Copper Sulphate		68	3	10		157	32	70

The most remarkable feature of the whole experiment is not the discovery of a first rate repellent but the relative unconcern with which both crickets and grasshoppers ate the bran even when heavily treated with materials commonly regarded as repellents and especially the almost unbelievable fondness shown for soap. This is shown, not only by the record of counts made, but was especially noticeable while the experiment was in progress. In the case of Series 4, practically the entire sample of bran treated with soap was consumed by the end of the fourth day. This peculiarity of taste was noted as soon as soap was added to the series and subsequently extreme care was taken to make sure that it was the result of an actual liking for the soap and not due to a possible slip in technique. It might be stated that a later field test proved the value of soap not only as an attractive substance when used in the preparation of poison mash but by its use as an ingredient, the mechanical condition of the mash was improved considerably.

To determine the effect of soap on the hoppers when no poison was used, one lot was confined in a screen cylinder cage and fed green corn and bran treated with soap. A check lot was fed on green corn alone and the death rate in the check was more rapid than in the case of the soap fed lot. Another season it is intended to give this a thorough test and also determine if possible, just what ingredient of soap is so attractive.

As for repellents, the copper sulphate is easily the most promising, kerosene coming second. It was noted during the progress of the experiment that while some few hoppers and crickets were counted near or on the bait treated with copper sulphate, it was very rarely indeed that any feeding was done. This was also true to a less extent in the case of kerosene.

By a comparison of the counts and influenced somewhat by the behavior of the hoppers as otherwise noted during the progress of the experiment, the various materials can be listed in order of their repellent qualities, as follows, the most repellent being placed last: soap, black strap, water, gasoline, sulphur, aloes, creosote oil, furniture polish, nitrobenzine, nicotine sulphate, auto oil, kerosene and copper sulphate. Since the first three and the last two mentioned were run in three series together, it is interesting to note the total results as shown in Table II.

Table II

	Crickets					Grasshoppers				
Series	Soap	Black Strap	Water	Kerosene	Copper Sulphate	Soap	Black Strap	Water	Kerosene	Copper Sulphate
2	743	288	203	146	68	364	243	214	193	157
3	64	12	10	6	3	983	244	348	78	35
4	225	118	137	31	10	881	503	392	160	70
Total	1032	418	350	183	81	2228	990	954	431	262

MR. J. J. DAVIS: In connection with the attractiveness of soap to grasshoppers, it may be of interest to state that Mr. Leach, who has been working with insecticides for the control of the Japanese beetle, has found that soap added to arsenate seemingly has an attraction for that insect.

PRESIDENT WILMON NEWELL: The next paper is by T. J. Headlee.

THE RESPONSE OF THE BEAN WEEVIL TO DIFFERENT PERCENTAGES OF ATMOSPHERIC MOISTURE[1]

By Thomas J. Headlee, Ph.D., *New Brunswick, N. J.*

Since the publication of "Some facts relative to the influence of atmospheric humidity on insect metabolism"[2] the writer has, as time would permit, collected data on the response of the bean weevil, *Bruchus obtectus*, to varying degrees of atmospheric moisture ranging in stages from less then 1% to approximately 100%. He has now completed three distinct sets of experiments and the curves, which are presented, have been constructed on the basis of the average of the experiments.

As in his previous experiments of this sort the utmost care has been taken to eliminate variable factors other than atmospheric moisture. The insects have been kept throughout their life cycle in darkness and and they have been subjected to a constant temperature of 80° Fahr., which did not vary as much as a degree either way. The pull of the water pumps has been approximately sufficient to counteract the changes in barometric pressure.

In each set of experiments the adult weevils were taken from exactly the same sources.

In each of the three series of experiments five containers were employed for each selected percentum of atmospheric moisture. Each of the five containers received twenty-five adult beetles as nearly evenly divided between the sexes as was practicable. Thus each selected percentum of atmospheric moisture in each of the three sets of experiments started with one hundred and twenty-five (125) adult weevils. The succeeding progeny in the five containers ranged from nothing in very low atmospheric moistures to over 1200 individuals in more favorable atmospheric moistures. The factor of individual variation in response was in this way reduced to the lowest practicable minimum.

The means employed to condition the atmosphere has not, it is thought, been heretofore considered in a formal way. The air was taken from outside of the building and led through a rubber pipe to a concentrated sulphuric acid drier. From thence the air stream was led into a distributing bottle from which each of the lines for the particular selected percentum of atmospheric moisture took their rise. One line led directly into an experimental chamber which was held at a constant temperature of 80° Fahr., and passed directly through the group of five containers in which the beetles and later their progeny

[1]Paper 17 of the Technical Series, N. J. Agricultural Experiment Stations, Department of Entomology.

[2]Journal of Economic Entomology, Vol. X, No.1, 1917.

were raised. This line then left the experimental chamber and passed over to the sink, where it was connected with a constantly functioning glass suck pump. The other lines, all of which contained air that must receive further conditioning as to atmospheric moisture, passed into different experimental chambers, all of which were held at a constant temperature of 80° Fahr., where the air was led through concentrated aqueous salt solutions; each stream passing through the particular salt solution which gave to it the desired amount of atmospheric moisture. Each line was then led to its particular group of five containers in which the beetles and their progeny were living. From the containers each air stream was led by a separate pipe to the sink, where it was joined to its own particular glass suck pump. The one in which the air must be conditioned to approximately 100% atmospheric moisture was led through a flask of distilled water and thence to its group of five containers.

The writer has tried various methods of conditioning the air, such as: (1) constantly raising the atmospheric moisture of the experimental chamber by the introduction of sponges or wet cloths and holding the percentum of moisture desired by passing the air over calcium chloride as often as it rose above the desired percentum; (2) passing moisture laden air through low temperatures and then passing it into a chamber, the temperature of which bore such relation to the previous low temperature that the percentage of atmospheric moisture was such as was desired. The first method is unsatisfactory, because there was no provision by means of which the air could be changed with sufficient rapidity to maintain the normal equilibrium of its component gases, especially as regards the proportion of carbon dioxide. The second method is ideal, but involves so large a quantity of expensive apparatus as to render it impracticable.

In view of the, to him, insurmountable objections to the two methods just described his attention was directed to the possibilities of utilizing the different vapor tensions of various aqueous salt solutions. He found no difficulty whatever in obtaining data on the vapor tensions of different aqueous salt solutions, but, in view of the fact that none of the vapor tension data were derived from saturated aqueous solutions, and in view of the further fact that without saturation the maintenance of a constant concentration was apparently out of the question, it became necessary to determine the amount of moisture which the different saturated aqueous solutions of various salts would give off under a constant temperature. Inasmuch as the machines with which he was working were well adapted to the maintenance of a

constant temperature of 80° Fahr., he determined to secure data on saturated aqueous solutions of various salts at that temperature. Accordingly a chemist was secured to make the determinations.

Data were obtained on the following salts:- sodium chloride, sodium bromide, barium chloride, lithium chloride, potassium sulphate, calcium chloride, aluminum chloride, potassium chromate, copper nitrate, sodium phosphate, sodium nitrate, sodium hydroxide and strontium chloride. With this at hand he selected from the group the following salts:- lithium chloride giving 7.1% atmospheric moisture; calcium chloride giving 25.9%; sodium hydroxide giving 30.7%; aluminum chloride giving 37%; copper nitrate giving 45.7%; sodium bromide giving 56.1%; sodium chloride giving 73.4%; sodium nitrate giving 80% and potassium sulphate giving 89.7%. The air as it came directly from the concentrated sulphuric acid drier contained less than 1% of atmospheric moisture, and the air which was passed through distilled water contained approximately 100% atmospheric moisture.

The length of time necessary for certain transformations to take place was adopted as the measure of the response of the bean weevil to these varying percentages of atmospheric moisture. It was thought to be impracticable to check this type of measure by the measurement of the evolution of carbon dioxide, because the food of the insect, being a living plant, threw off considerable quantities of carbon dioxide on its own account and obscured the evolution of that gas from the insects under observation.

Two curves were derived; the first representing the period of time from the laying of the egg to the formation of the pupa, and the second representing the period of time from the laying of the egg to the emergence of the adult. The first curve has proven to be very smooth and definite, while the second curve shows very pronounced variations. No individuals succeeded in reaching maturity in an atmospheric moisture of less than 1%, and very few individuals succeeded in an atmospheric moisture of 7.1%. Comparatively few succeeded in reaching maturity in an atmospheric moisture of 25.9%. In these three cases the only apparent cause was the low atmospheric humidity. In both 89.7% and approximately 100% in spite of everything that could be done in the way of sterilizing the food, fungi developed and always greatly reduced the number, and in some cases, utterly prevented the insects from reaching maturity. Such as did reach maturity in the

100% atmospheric moisture seemed to be considerably delayed, possibly by the action of the fungi. The data from these sets of experiments, as those derived from previous ones, indicate that the optimum atmospheric moisture for the bean weevil lies somewhere between 80 and 89%, and is located in that percentum which is just far enough below 89 to prevent the development of injurious fungi.

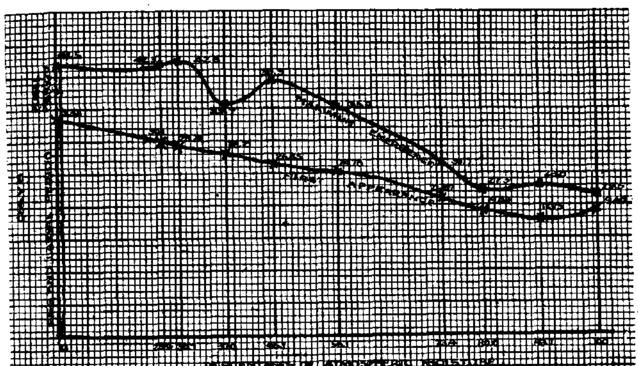

FIG. 5 Chart showing effect of atmospheric moisture in the development of the Bean Weevil.

As is shown by the curve based on the length of period from egg to pupa, the value of 1% increases in atmospheric moisture at any point between 7.1% and 80% is approximately two-hundredths of a day. Of course, there is considerable variation in this evaluation of the 1% increase, but the variation is such as to indicate that that figure is not very far from the facts. The variation is thought to be due in all probability to the direct and possibly to the indirect effect of certain of the salts which seemed, in some cases, to have a retarding, and in other cases to have an accelerating action. These variations as shown in the curve representing the period from egg to pupa became much more pronounced in the curve representing the period from egg to adult. As yet the writer has had no opportunity to evaluate this factor, and consequently has not been able to smooth the curves. The curve representing the period from egg to adult cannot be considered as representing in a satisfactory manner the effect of the different percentages of atmospheric moisture until it has been smoothed in that way. Nevertheless, the writer believes that it is fair to assume that the curve representing the period from the egg to pupa is already sufficiently

smooth to give a pretty accurate idea of the effects of the different percentages of atmospheric humidity on the rate of developmont of this insect.

As the next step in this investigation, it is proposed to evaluate the retarding and accelerating effect of certain of these salts and to check the measuring stick used in these sets of experiments by the carbon dioxide index.

Mr. R. N. Chapman: I should like to ask Mr. Headlee about the moisture content of the beans. In trying some experiments with the bean we found that the bean seemed to act as a buffer medium. The bean would have to come into equilibrium with the vapor tension of the air and the larvae would come into equilibrium with the moisture content of the bean. The moisture content of the bean would depend upon how many larvae there were present. While in a general way you get this effect which shows very nicely in these curves, in any particular instance you couldn't be sure of what would happen because it depended upon the number of larvae that happened to be present in the particular bean. Therefore, I have resorted to some insects which lived free in food like many of those working in stored food products. Before the larvae enter the bean they are pretty small, and when they are exposed to the lower percentage of humidity the death rate is very high. I presume you found the same thing.

Mr. T. J. Headlee: I attempted to meet the variables you mention by using large numbers of insects and averaging results. Inasmuch as the three extensive series seemed to agree among themselves I felt that we were not very far off in spite of the difficulties which you have mentioned.

Mr. R. N. Chapman: Your curve shows that your results check very nicely. That is the best proof.

I should also like to ask you a question about your saturated solutions of salt. When we tried them out with small volumes of air they seemed to work very nicely. Then we tried them with larger volumes, using a combination pressure and volume blower which would give us a displacement of about sixteen inches of water, and we tried to run through about two hundred cubic feet of air, we found that we couldn't do it. Of course, I presume the whole secret of it is that up to a certain point the ratio of air to moisture and the fineness into which you can divide your air to pass it through is going to control the rate at which the air and moisture come into equilibrium.

Mr. T. J. Headlee: Your explanation seems reasonable.

MR. R. N. CHAPMAN: Do you know how large a volume can be passed through this, and at what rate?

MR. T. J. HEADLEE: No. I have not tried to work it out. I have used as high as 5 liters in 10 minutes; that is, a liter every two minutes

PRESIDENT WILMON NEWELL: The next paper is by J. L. Horsfall and J. R. Eyer.

PRELIMINARY NOTES ON CONTROL OF MILLIPEDES UNDER SASH

By J. L. HORSFALL and J. R EYER, *State College, Penna.*

In the fall of 1910, truck growers in eastern Pennsylvania experienced severe losses from the depredations of millipedes. One grower lost his entire stand of carrots and fifty per cent of his stand of lettuce grown under sash. Two problems presented themselves: one, the prevention of injury to lettuce in the fall as the seed was germinating; two, the prevention of injury to growing tomato seedlings in the spring.

CONTROL BY SOIL FUMIGANTS AND CONTACT PREPARATIONS

EEFFECT ON MILLIPEDES:- In tables I and II the data were obtained from cold frames seeded to lettuce in the fall. All plots comprised an area of 48 square feet. From table I it will be seen that sodium cyanide at the rate of 150 pounds to the acre, when sprinkled in furrows and covered, resulted in an increase of 256 plants as compared with the check plot. The slight increases in stand in plot 1c and plot 1d can hardly be attributed to control of millipedes in view of the fact that these pests damaged the outer rows in all the check plots to a greater extent than they did the center rows. Since the increased number of plants in plot 1c and plot 1d were found in the center rows while the side rows had the same stand as those in check plot 1, it is clear that control was lacking. No control was obtained in plots treated with creosote oil, diluted either 1 - 25 or 1 - 50, or with cresylic acid 1 - 100. Creosote oil 1 - 100 and cresylic acid 1 - 200 gave some control but this was small when compared with results obtained with cyanide. At the time the counts were made, living millipedes were common in all the plots treated with creosote oil and cresylic acid while few were found in the cyanide plots.

Two of the treatments applied the day seed was drilled resulted in a decided retardation of millipede activities as shown in table II. On

TABLE I—THE EFFECT ON MILLIPEDES OF SOIL FUMIGANTS AND CONTACT INSECTICIDES APPLIED ONE WEEK BEFORE SEEDING

Plot No.	Materials	Strength	Amt. used per plot	No. plants in stand Side rows	Center rows	Total	Manner of application
		Lb. per Acre	Gal.	No.	No.	No.	
1	Check			192	288	480	No treatment
1a.	Sodium cyanide	150	7½	320	416	736	Sprinkled in furrows and covered at once
1b.		250	7½	128	192	320	Ground cultivated before seeding.
1c.		150	15	176	336	512	Sprinkled over surface of soil. Raked over within 42 hrs.
1d.		250	15	192	320	512	Ground cultivated day before seeding.
2	Check			64	320	384	No treatment
2a.	Creosote oil	Dilution 1-25	15	0	192	192	Sprinkled over surface of soil
2b.		1-50	15	160	160	320	Raked over within 24 hours.
2c.		1-100	15	192	224	416	
2d.	Cresylic acid	1-100	15	0	128	128	Ground cultivated day before seeding.
2e.		1-200	15	128	320	448	

TABLE II—THE EFFECTS ON MILLIPEDES OF SOIL FUMIGANTS AND CONTACT INSECTICIDES APPLIED AT TIME OF SEEDING

Plot No.	Materials	Strength	Amt. used per plot	No. plants in stand Side rows	Center rows	Total	Manner of application
			Gal.	No.	No.	No.	
3	Check			160	320	480	No treatment
3a.	Creosote oil	1-200	15	0	64	64	Sprinkled over surface of soil after seeding
3b.	Nicotine sulphate	1-200	25	384	320	704	Lime broadcasted worked into soil before seeding. Solution sprinkled over surface of soil after seeding.
3c.	Sodium Cyanide	150 lb. per A.	20	0	4	4	Sprinkled over surface of soil after seeding.
4	Check			160	416	576	No treatment
4a.	Nicotine Sulphate Hydrate Lime Dust	2% Nicotine	lb. 1½	240	480	720	Scattered in row with seed.

plot 3b where nicotine sulphate was applied, there was an increase of 224 plants over the stand on check plot 3. Attention is directed to the even stand in both center and side rows of the plot which received this treatment. There was also a decided gain on plot 4a. This section was treated with a 2 per cent nicotine dust made by sprinkling nicotine sulphate on hydrated lime.

EFFECT ON GERMINATION:- Sodium cyanide at the rate of 250 pounds to the acre, as used on plot 1b, did not prevent germination but checked it to some extent. Where used at the same strength on plot 1d the cyanide caused no injury, which was due to the difference in method of application. Creosote oil 1 - 25 and 1 - 50 and cresylic acid

1 - 100 gave distinct injuries as compared with the stand on a check plot 2. Creosote oil, table II, when diluted 1 - 100, showed a strong tonic action on the germination of the seeds. The same was true on plot 30 on which sodium cyanide was used at the rate of 150 pounds to the acre. The reason for this was that the chemicals came in direct contact with the seed. An examination of plots 3, 3a, 3b, and 3c eight days after the several treatments were applied showed that the surface soil of the treated plots had become caked, thus preventing the plants from breaking through the soil. A comparison of these plots with their check, number 3, where the stand was already showing, indicated the necessity of loosening the crust. The soil over the seeds was raked by hand and an almost perfect stand resulted on plot 3b, as shown in table II.

Naphthaline flakes, either applied as a dust in the row, or mixed with hydrated lime and broadcasted immediately before sowing, was a check on the germination of the seeds. This treatment had a distinct value as a repellent to the millipedes. The soil, however, where the naphthaline was used, became dry. This condition was undoubtedly a factor in low seed germination. Limed and unlimed check plots provided comparisons with regard to this condition. Various other materials were tested but these gave no control.

Control by Poison Bait

Spring Treatment:- In the spring of 1920, a tomato grower complained that millipedes were damaging seedlings under sash. The pests were cutting the tomato seedlings at the surface and feeding on a portion of the root system. Arrangements were made to test the effectiveness of poison baits as usually recommended for these pests. The various baits were scattered in handfuls over the surface of the ground between the plants and adjacent to the sides of the frames. Observations showed that the millipedes fed upon all of the mixtures, while attacks upon the tomato seedlings ceased. The most satisfactory formula was composed as follows:

Bran	2 pk.
Molasses	½ - 1 pt. depending on quality.
Sodium arsenite	2 oz.

Water, in sufficient quantity to make mash.

Fall Treatment:- In the autumn of 1920, the above formula was again tried on lettuce beds under sash. The bait was scattered over the surface of the soil in one series and in another test was placed either under boards or in furrows along the edges of the cold frames, after-

ward being covered with soil. These experiments resulted in no control. The apparent contradiction of these results was due to seasonal habits rather than to the ineffectiveness of the poison. In the spring the millipedes were becoming active after hibernation and fed ravenously on the tender plants at the surface. In the autumn, the pests, going deeper into the soil to pass the winter, were not attracted to the growing plants above the surface. Consequently, when bait was applied in the spring, they were readily attracted, while applications in the fall seeded frames proved inefficient.

Summary

Either sodium cyanide, nicotine sulphate solution, or nicotine sulphate in the form of a dust resulted in comparatively perfect stands of lettuce.

The plot treated with sodium cyanide at the rate of 150 pounds to the acre, when applied in furrows and covered with soil one week before planting, showed an increase of 256 plants over the untreated plot.

Nicotine sulphate, diluted one part in two hundred parts of water, when sprinkled on a newly seeded bed, resulted in an increase of 224 plants as compared with the check. This plot had been previously limed, but as shown in the other tests, lime did not factor as a control measure.

Two per cent nicotine sulphate as a dust increased the stand 144 plants.

Sweetened poison bait controlled millipedes in the spring but proved inefficient in autumn as a protection in fall seeded frames.

MR. E. C. COTTON: Was the same amount of seed used in each case?

MR. J. L. HORSFALL: The seed drill was set exactly the same in the treated plots as it was in the checks.

PRESIDENT WILMON NEWELL: The next paper is by F. M. WADLEY.

LIFE HISTORY OF THE VARIEGATED CUTWORM[1]

By F. M. WADLEY, *U. S. Bureau of ontomology*

The variegated cutworm[2] is distributed over most of North America and the rest of the world. Its power of sudden increase to de-

[1]Published by permission of the Secretary of Agriculture.

[2]*Lycophotia margaritosa saucia* Hbn.; family Noctuidae; order Lepidoptera.

structive numbers, together with its voracious appetite for nearly all crops, have made it a dreaded pest. The developmental stages have been well described and figured by various workers.

The work on which this article is based was done by the writer while a field assistant with the federal Bureau of Entomology, Truck Crop Insect Investigations, at Wichita, Kansas, in 1915. Some data has been drawn from work done by Mr. F. B. Milliken, with the writer's assistance, in 1914, at Garden City, Kansas; and from notes of occurrence made at various times by Mr. Mililiken and the writer.

The larvae were reared in the insectary in jelly glasses, in which soil had been placed, and were fed various kinds of green leaves. The adults were kept in cloth-covered cages outdoors, and given sugar-water and alfalfa blossoms. Eggs were deposited on the cloth of the cage, and could be clipped off or allowed to hatch in place. The season of 1915 was unusually cool. that of 1914 about normal.

Development

Egg. The egg is hemispherical, a little less than 1 millimeter in diameter, and is a clear, pale yellow when first deposited, changing to brown by the second day and darkening slowly thereafter. Some egg masses, presumably unfertilized, fail to show this color change. Of about 3,000 apparently normal eggs observed, 75% hatched, different egg masses varying from 7 to 100% fertility.

In hot weather eggs will hatch in 4 days. In 1915 the average was 5.2 days, varying from 4 to 6 days. In May, 1914, 7 days were required. Eggs in a single mass will often vary a day in hatching.

Larva. The larvae on first hatching move with a looping gait, but soon take on the customary cutworm movement. This species grows faster, is more active, and feeds more greedily than most cutworms. The larvae are found by day hidden in loose soil, among surface trash, or under some object. They seem to the writer to be leaf feeders rather than typical cutworms in their feeding habits. Many records show that they climb plants to feed, and that in some cases they burrow for food, such as potato tubers. In case food is scarce the larvae will consume every green portion of the plant, and migrate some distance in search of food. In the insectary alfalfa, several common vegetables and weeds were greedily eaten. with special partiality for pigweed, cabbage, and turnip leaves. The larvae eventually reach a length of 1½ to 1¾ inches and a diameter of about ¼ inch. There is much variation in depth of color, but a row of yellow spots down the

mid-dorsal line is invariable, and easily distinguishes this species from others. As full growth is gained the larvae become quiet, shrink in size, and exhibit pupal motions when disturbed. The larva descends about 2 inches into the soil, constructs a roomy cell, and the pupa is formed therein.

In May and June, 1914, individual records of larval life varied from 24 to 28 days, averaging 26¼ days. In July, 1915, a large brood varied from 20 to 27 days in the larval stage, averaging 24 days. In September and October, 1915, the larval stage required from 5 to 6 weeks.

PUPA. The pupa is of the common Noctuid type, about an inch long. It is light brown when first formed, but darkens as development proceeds, until almost black. In June, 1914, individuals required from 13 to 16 days for the pupal stage; in June and August, 1915, the pupal stage was from 15 to 20 days, averaging 16 or 17; in October, 1915, nearly a month was required.

ADULT. The adult is a rather large moth, expanding about 1¾ inches. Two forms occur; one, the more numerous, is a sober brownish-gray in general color, the other a shade of purple, which does not retain its intensity in dry specimens. The pattern is the same in both, but the shade is quite distinct, and among several hundred moths only one has been seen that could be classed as intermediate.

The method of rearing had the disadvantage of giving few individual records of adult life. The longevity in 6 cages of moths varied from 8 to 13 days. Eggs are deposited within three days after emergence, and up to 2 or 3 days before death; in one cage eggs were deposited 12 days after the emergence of the youngest moth present. Females confined alone have in some cases deposited normal looking eggs, which failed to develop, as before noted. The eggs are usually deposited in masses, irregular, usually compact, although sometimes scattered. Eggs masses contained from 30 to 320 eggs, averaging 130. The moths preferred white cloth to any other available substance for oviposition. Judging from the number of egg masses found in a cage as compared with the number of moths present, a female may deposit more than one egg mass.

SUMMARY OF LIFE-CYCLE

TABLE OF LIFE-PERIODS IN SUMMER

Stage	Minimum	Maximum	Average
Egg	4 days	6 days	5.2 days
Larva	20 "	28 "	24 "
Pupa	13 "	20 "	16 "
Total	37 "	54 "	45 "
Life-cycle[1]	40 days	57 days	48 days

[1]The life cycle in the last row is computed by adding 3 days as preoviposition period.

Summary of Life Cycle

Observations on the time of maximum emergence and the time of maximum oviposition of two consecutive generations in 1915 confirm the conclusion that the average time required for a generation in summer is not far from 50 days in Southern Kansas.

Doctor Chittenden gives the larval stage for this species as 3 to 4 weeks at Washington, D. C., while Lintner states that it is 23 to 28 days in New York; both state that the pupal stage is from 11 to 20 days. Slingerland states that various workers have estimated the life cycle at 35 to 62 days; Doane and Brodie believed that in Washington State it was about 75 days.

Seasonal History

At Wichita in 1915, 3 consecutive generations were reared. Larvae of these species, presumably of the first generation, were active late in May and in June, and pupated late in June; adults emerged early in July and deposited eggs soon after emergence. Second-generation larvae hatching from these eggs pupated early in August, and became adults late that month. Eggs were deposited by these adults, and the larvae hatching from them developed more slowly during September. Many of them died, but some pupated in October and became adult in November, although subjected at times to freezing temperatures. In May, 1914, eggs of this species, evidently deposited by an overwintered individual, were found on a towel. They hatched May 14; the larvae pupated about June 10 to 15, and became adult late in June. From eggs deposited by them a few adults were reared in August. At Garden City in 1913 moth traps were run from early summer until late in November. A scattering occurrence of Lycophotia adults is noted all season, but they occurred in exceptional abundance at 3 periods; about July 10, August 15, and November 1. These periods of abundance must correspond to the first, second and third generations reared at Wichita in 1915. A few first generation larvae were reared at Wichita in 1916, and at Muscatine, Iowa, in 1919; in both cases the adults emerged late in June. Adults were seen flying in July at Wichita in 1917; In Iowa in 1919; and in Northern Illinois in 1920. In the latter locality a small larva, evidently of the second generation, was taken July 26, 1920.

From this it would seem that the species has three generations in

Kansas and neighboring states, though the third may be only partial; larvae hatching in May, July and late August respectively. Because of variations in development, extended oviposition and adult longevity, some adults are flying at almost any time in the season..

Only the first generation is usually injurious, larvae of the later generation being scarce and hardly noticeable in the field. This is probably due to parasitic attacks. In Kansas in 1915, and in Iowa in 1919, Lycophotia was heavily parasited by *Archytas analis*, a tachinid, and there are doubtless other important parasites. Records show that the later generations may be important in some cases; on the other hand, even the first generation larvae are scarce in many seasons,

Riley believed there were two and possibly three generations in Missouri; Fletcher, Lintner, Garman, Doane and Brodie, aud others have expressed the belief that two generations occur.

HIBERNATION: The writer has no direct evidence on the method of hibernation. Moths were abroad November 18, 1915 and December 4, 1917; and were reared under outdoor temperatures, emerging in November 1915. Moths were flying at Garden City in April, both in 1914 and 1915; and Mr. W. P. Flint states that they have been observed in March in Illinois. Noctuid larvae and pupae have been carefully collected by the writer during winter and early spring in several seasons, but none of Lycophotia have been found among these collections. The facts that adults are present so late in the fall and early in the spring, and that larvae or pupae of this species have not been found during the winter, suggests that the species hibernate as adult.

Gillette records adults flying in late fall: on the other hand, both Chittenden and Forbes record finding larvae at different times in winter, and Doane and Brodie wintered the species as pupae in the insectary. It may be that more than one stage hibernates, as Doctor Chittenden suggests. From the facts the writer has, it seems likely that the adult is the principal, if not the only hibernating stage in southern Kansas, More work should be done on this phase of the seasonal history.

DIMORPHISM

As noted before, two forms of adults occur. On confining these types of moths in separate cages, it was found that the purple form did not reproduce. In only one case were eggs found in the cage of purple moths, and these eggs were abnormal, appeared withered, and failed to develop. The gray moths deposited eggs in great abundance,

whether purple moths were present with them or not, and these eggs always developed normally when both sexes were present. When gray females were confined alone they deposited infertile eggs in some cases. Some gray females deposited eggs which gave rise to both gray and purple moths, in one large brood in about equal numbers; others had only gray progeny.

Bibliography

1868. Riley, C. V. : First Rept. State Ent. Mo.
1878. French, G. H. : 7th Rept. State Ent. Ill., pp. 94, 211.
1883. Lintner, J. A. : 5th Rept. State Ent. N. Y., pp. 200-216.
1890. Forbes, S. A. : 16th Rept. State Ent. Ill., pp. 93-94.
1895. Slingerland, M. V. : Cornell Bull. 104, pp. 579-584.
1899. Lugger, O. : 4th Ann. Rept. Minn. Exp. Sta., p. 160.
1901. Chittenden, F. H. : U. S. Bu. Ent., n. s., Bull. 27, pp. 114.
1901. Chittenden, F. H. : U. S. Bu. Ent., n. s., Bull. 29, pp. 46-64.
1901. Doane, R. W., and Brodie, D. A. : Wash. Exp. Sta., Bull. 47, pp. 3-16.
1901. Fletcher, J. : Rept. Canada Ent. for 1900, pp. 215-227.
1902. Stedman, J. M. : 34th Rept. Mo. Bd. Agr., pp. 118-124.
1904. Garman, H. : Ky. Exp. Sta., Bull. 114, pp. 34-35.
1907. Forbes, S. A. : 23rd Rept. State Ent. Ill., pp. 23-25, and p. 243.
1912. Davis, 27th Rept. State Ent. Ill., pp. 84-88.
1913. State Ent. of Nebr., Bull. 1, pp. 35-41.
1915. Canada Dept. Agr., Ent. Bull. 10, pp. 17-20.

Adjournment.

LIFE HISTORY OF *PYRAUSTA AINSLIEI* HEINR. AT AMES, IOWA, DURING THE SEASON OF 1920

By. I. L. Ressler, *Iowa State College, Ames, Iowa*

Since the introduction of the European Corn-borer into the United States there has been much discussion as to the consequence should this pest appear in the corn belt. This led to the study of the life history of *Pyrausta ainsliei* Heinr., a native borer (smartweed stem-borer), as one of the projects of the Iowa Agricultural Experiment Station at Ames. The larvae and adult females of *P. ainsliei* so closely resemble the larvae and adult females of *P. nubilalis* Hubner (the European Corn-Borer) that the two are easily confused.[1]

Injury

The writer has not observed the work of the insect in corn, since it

will only feed in corn when there is a scarcity of its natural food plant, *Polygonum hydropiper* L. (smartweed). The larvae burrow into the Polygonum stem and eat their way upward until ready to pupate. The point of entry is a circular opening. The writer has noticed that infested stems prematurely turned red just as older uninfested plants do. It has been said that this turning red has been caused entirely by *P. ainsliei*. This is apparently not the case, but merely seems as if the process is hastened by the infestation. As many as seven larvae have been taken from a single stem in infested fields, although the number usually only ranged from one to three. The nature of the injury to corn, which is decidedly unlike that of the European Corn-Borer, has been fully described by W. E. Britton in his Nineteenth Report.[2]

Distribution And Food Plants

P. ainsliei occurs throughout the Eastern and Middle Western States having been found in Massachusetts, Connecticut, New York, New Jersey, Tennesee, Illinois, Missouri, Kansas and Iowa.[1] W. P. Flint and J. R. Malloch have published a list of twenty food plants of this species, mentioning the fact, however, that specimens have not been found in any of them except where they were growing near infested Polygonum.[3]

Life History At Ames

Two broods of the insect occur during the season at Ames, Iowa. The larvae winter over in their burrows in smartweed after closing the opening with excrement. In the spring they became active for a short time and entered the pupal stage during late May and early June, the moths emerging after a pupal period of from ten to fourteen days during the latter part of May and the first half of June.

After a short flight the moths deposited their eggs on the underside of smartweed leaves in masses containing from eleven to fifty eggs. The writer has not been able to determine the total number of eggs laid by a single female, nor has he been able to induce reared females to deposit eggs in the insectary, but observations upon dissections of females indicate that a single individual deposits several hundred. The eggs are glistening white, flat, nearly circular in shape and overlap each other on the leaf at deposition. Daily field trips were made and the first egg masses were observed on June tenth, after which they could be found freshly laid until July tenth. The incubation

period lasted from six to ten days. Considerable difficulty was experienced in hatching eggs out in the insectary at the start due to rapid changes in temperature and moisture conditions. This was soon remedied, however, and the results obtained in the insectary tallied with the observations in the field. Just before hatching the egg turned a brownish color.

The larvae of the summer generation hatched in the latter part of June and continued through a period until about July tenth. The newly hatched larvae began to feed almost immediately in the midrib of the leaf but soon migrated to the stem where they made a circular opening, entering the stem almost invariably just above a node.

The pupae of this generation were observed about the end of July and the last on August twenty-third. Just before pupating, the larvae spun a delicate, white silken curtain across its burrow just in front and back of itself, forming a cell. The pupal stage extended over a period of from nine to fourteen days, the average length being twelve days. The first moths emerged August tenth and were observed in flight until September fourth. These moths began to deposit eggs

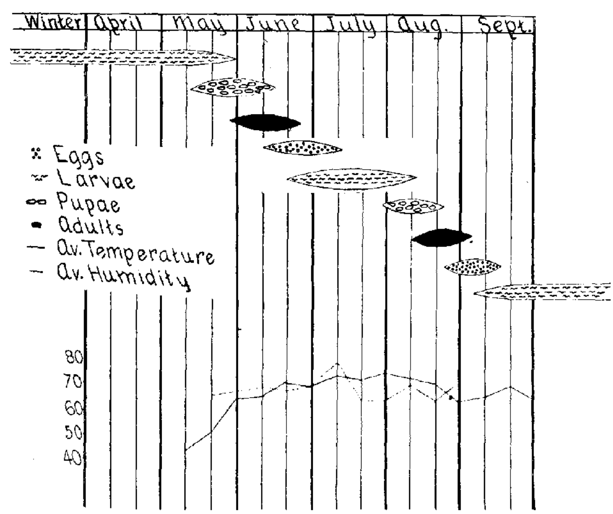

Fig. 6 Diagram of Life History of *P. ainsliei* Showing also Average Temperature and Average Humidity for the Season of 1920 at Ames, Iowa.

in the latter part of August and first half of September. The first overwintering larvae hatched out above the eighth of September and were in evidence until nearly the end of the month. The larvae fed actively until cool weather when they plugged their entry holes in preparation for hibernation.

The chart above (Fig. 6) diagrams the life history as correlated with the average temperature and humidity records of the station for the season of 1920.

Natural Enemies

One very important hymenopterous parasite of *P. ainsliei* of the family *Braconidae*, genus *Aleiodes*, was reared. While boring insects do not usually have natural enemies of sufficient importance to be considered as a factor in the control of the insect, this parasite will undoubtedly reduce the percentage of infestation during the coming season. Fully fifty per cent of the larvae collected were parasitized, each one having from four to eight Braconid larvae on it.

Conclusion

The European Corn-Borer has two complete generations in Massachusetts, which closely parallels the life history of *P. ainsliei* as worked out at Ames. While each of the stages appeared a little later during 1920 at Ames than like stages appeared in the European Corn Borer in Massachusetts, this can no doubt be explained by the fact that each was studied during different years, under varying degrees of temperature conditions. Given similar conditions for each, it is the writer's opinion that the two insects would parallel each other in Iowa, should *P. nubilalis* be introduced into the state. The problem before us is a grave one, far reaching in its consequences, and no efforts should be lost in the work to prevent the further spread of this pest.

References

1. Heinrich, C., Journ. Agr. Research, Vol. XVIII, No. 3, Wash. D. C., Nov. 1, 1919.

2. Britton, W. E., Nineteenth Rep. State Ent., Bull. 218, Conn. Agr. Exp. Sta., 1920.

3. Flint, W. P., and Malloch, J. R., The European Corn Borer and Some Similar Native Insects, Vol. XII, Art. X, Bull. Ill. Nat. Hist. Survey, June 1920

THE EFFECT OF POISON BRAN MASH ON GRASSHOPPERS AND THE LAPSE OF TIME BETWEEN POISONING AND DEATH[1]

By A. L. FORD, *Scientific Assistant, Bureau of Entomology, West Lafayette, Indiana*

The feeding powers of normal, healthy grasshoppers are well known by practically every farmer. Also those who have used poison bran mash for their control know that it is not an instantaneous killer, in fact it usually takes one or two days for a hopper to die after feeding on the poison. These two facts often tend to discourage the use of poison mash for grasshopper control. Since a large army of hoppers is capable of consuming vast amounts of green food in a single day, many farmers say "Why poison when it will not kill for two days as my crop will be taken in that length of time anyway."

The writer has had to contend with this idea many times and yet he had no positive data showing that the farmer was wrong. It was with this in view that the author started to compile data showing that although poisoned hoppers appear perfectly healthy until a short time before death, they consume very little food after poisoning as compared with unpoisoned hoppers during the same period of time.

The work was done at the field laboratory of the Bureau of Entomology at Lafayette, Indiana during the late summer and early fall of 1919. A serious infestation of *Melanoplus femur-rubrum* occurred in this locality at that time thus facilitating the work greatly. All experiments were performed on adults of *Melanoplus femur-rubrum*.

Adults of the above species were collected from the field by hand sweeping and placed in screen cages without food, where they were left for one day in order to become sufficiently hungry to feed in captivity. A small amount of poison bran mash was then mixed and placed in the cage. As the hoppers therein came to feed on it they were timed in minutes. After feeding for the required time (two minutes) each hopper was removed and placed in an individual lantern globe cage together with a piece of green corn leaf cut to known dimensions. This food was changed frequently until the hopper's death. Each time the corn leaf was removed the area eaten was traced on cards, each hopper having an individual card. Later the total area eaten by each hopper was determined in square inches of corn leaf by means of the planimeter. In this way the amount each hopper ate between the time of poisoning and death was accurately calculated. Unpoisoned hoppers freshly swept from infested fields were run as

checks along with the poisoned one in each experiment, thus giving the difference in the amount of food eaten by poisoned and unpoisoned hoppers for the same period of time.

In this work poison mash mixed with Paris green, white arsenic and crude arsenic were used and data obtained on the effect of these different arsenicals on the feeding capacity of grasshoppers. Also data were obtained on the length of time required for these various poisons to kill, together with the effect of different amounts of poison mash consumed on the time of death and food eaten after poisoning.

The following table shows the difference in the amount of corn leaf eaten during the same length of time by unpoisoned hoppers and those poisoned by mash containing Paris green.

TABLE I

Expt. No.	No. hoppers poisoned	No. check hoppers	Aver. time between poisoning and death	Aver. time check hoppers were allowed to feed	Aver. amt. corn leaf eaten by poisoned hoppers	Aver. amt. corn leaf eaten by check hoppers
1996	1	1	48 hrs.	48 hrs.	0.07 sq. in.	0.96 sq. in
1997	9	3	38 "	38 "	0.08 " "	1.99 " "
19152	9	9	44.9 "	44.9 "	0.12 " "	0.61 " "
19155	10	10	23.8 "	23.8 "	0.014 " "	0.93 " "
	Averages		35.5 hrs.		0.071 " "	0.944 " "

The poison mash used in the experiments, the results of which were shown in Table I, was mixed according to the following formula: ½ lb. Paris green; 25 lbs. wheat bran, and 2 qts. black strap molasses, no fruit being used. In the four experiments, individual records were kept on 29 poisoned hoppers and 23 check (unpoisoned) hoppers, both groups being allowed to feed for the same length of time. The average period between poisoning and death for the lot was 35.5 hours. During this time the poisoned hoppers ate an average of 0.071 square inches of corn leaf each, while the unpoisoned hoppers ate an average of 0.944 square inches, showing that the unpoisoned consumed slightly over 13 times as much food as the poisoned ones.

The following table shows the difference in the amount of corn leaf eaten by unpoisoned hoppers and those poisoned by mash containing white arsenic, during the same period of time.

TABLE II

Expt. No.	No. hoppers poisoned	No. check hoppers	Aver. time between poisoning and death	Aver. time check hoppers were allowed to feed	Aver. amt. eaten by poisoned hoppers	Aver. amt. eaten by poisoned hoppers
1998	9	9	55 hrs.	55 hrs.	0.295 sq. in.	0.816 sq. in.
19156	10	10	33.9 "	33.9 "	0.022 " "	1.26 " "
	Averages		43.9 "		0.151 " "	1.049 " "

The poisoned mash used in experiments, the results of which are shown in Table II, was mixed according to the following formula: White arsenic ¾ lbs.; wheat bran 25 lbs. and black strap molasses 2 quarts, no fruit being used. In these two experiments individual records were kept on 19 poisoned hoppers and 19 check (unpoisoned) hoppers, both groups being allowed to feed for the same period of time. The 19 poisoned hoppers ate an average of 0.151 square inches of corn leaf each between the time of poisoning and death, while the unpoisoned hoppers ate an average of 1.049 square inches during the same period of time, showing that the unpoisoned consumed approximately seven times as much food as the poisoned ons.

The following table shows the difference in the amount of corn leaf eaten by unpoisoned hoppers and those poisoned with bran mash containing crude arsenic, during the same period of time.

TABLE III

Expt. No.	No. hoppers poisoned	No. check hoppers	Aver. time between poisoning and death	Aver. time check hoppers were allowed to feed	Aver. amt. corn leaf eaten by poisoned hoppers	Aver. amt. eaten by check hoppers
1996	1	1	48 hrs.	48 hrs.	0.11 sq. in.	0.96 sq. in.
19100	11	11	70.7 "	70.7 "	0.31 " "	1.867 " "
19158	10	10	27.5 "	27.5 "	0.024 " "	1.202 " "
		Averages	50 hrs.		0.166" "	1.525 " "

The poison mash used in the experiments, the results of which are shown in Table III, was mixed according to the following formula: 1½ lbs. crude arsenic, 25 lbs. wheat bran, and 2 quarts black strap molasses, no fruit being used. In these experiments individual records on 22 poisoned hoppers were kept, together with 22 check (unpoisoned) hoppers. The unpoisoned ones ate an average of 1.525 square inches of corn leaf each, while those which were poisoned ate only an average of 0.166 square inches, showing that the unpoisoned hoppers consumed approximately nine times as much food as the poisoned ones during the same period of time.

Averaging the three sets of experiments tabulated above, it is seen that complete and individual records were kept on 80 poisoned and 74 unpoisoned hoppers. The poisoned ones ate an average of 0.122 square inches of corn leaf between the time of poisoning and death, while those that were not poisoned ate an average of 1.175 square inches during the same length of time. Thus the unpoisoned hoppers ate 9.6 times as much food as those which were poisoned.

Taking up the question of the length of time required to kill by the three poisons, we find from the data set forth in the three tables above, the following interesting facts. The 29 hoppers poisoned by bran

mash containing Paris green lived for an average of 35.5 hours after being poisoned, the 19 individuals receiving the white arsenic mash lived for an average of 43.9 hours after poisoning, and those poisoned by crude arsenic mash continued to live for an average of 50 hours after poisoning. The poison mash mixed with Paris green killed quicker than the others, that mixed with crude arsenic being an average of 14.5 hours slower. The average length of time taken for the white arsenic to kill was about midway between the Paris green and crude arsenic.

The amount of poison bran mash required to kill grasshoppers and the effect of different amounts consumed on the rapidity of kill and amount of food eaten after poisoning was next considered. These experiments were performed by allowing the hoppers to feed on poisoned mash (½ lb. Paris green and 2 quarts black strap molasses for each 25 lbs. of wheat bran) for different lengths of time, thus consuming different amounts. These were then placed in individual cages and treated similar to the hoppers in the experiments previously shown.

The following table shows the length of time between poisoning and death and the amount of food eaten after poisoning by hoppers receiving different amounts of poison bran mash.

TABLE IV

No. hoppers used	Time allowed to feed on poison bran mash	Average time between poisoning and death	Average amount of corn leaf eaten between poisoning and death
[1]5	30 seconds	10.5 hrs.	0.037 sq. in.
5	1 minute	28.6 hrs.	0.067 " "
5	2 minutes	23.7 hrs.	0.038 " "
5	3 minutes	38.6 hrs.	0.294 " "
5	4 minutes	20.8 hrs.	0.078 " "

These data apparently show that the hoppers receiving the smallest amount of poison bran mash died quicker and ate less after being poisoned than any of the other groups. However, one of the hoppers in this group failed to become poisoned at all, and must be taken into consideration. Those hoppers which fed on the poison for 3 minutes lived longer and ate more than any of the other groups.

Summarizing the data set forth in this paper, it can be said that although grasshoppers may appear healthly and active for many hours after eating poison bran mash, they consume very little food as compared with unpoisoned hoppers, the data showing less than one ninth as much. Because of this no farmer who has poisoned should be discouraged if the hoppers remain active in fields for a considerable period

[1]One hopper from the 30 seconds group failed to become poisoned.

of time after treatment with poison bran mash. Furthermore the last experiment seems to indicate that it takes very little poisoned bran mash to kill a hopper and those receiving smaller amounts die just as soon and eat just as little after poisoning as those consuming larger amounts.

OBSERVATIONS ON THE ATTRACTIVENESS OF MATERIALS USED IN GRASSHOPPER BAITS[1]

By A. L. Ford, and W. H. Larrimer *Scientific Assistants, Bureau of Entomology West LaFayette, Indiana*

During recent years conflicting results as regards efficiency of kill seem to have been obtained from the use of various substances in grasshopper baits. Favorable results have been reported from such widely differing mixtures as those made without fruit flavors or syrups, those in which sawdust has been substituted for wheat bran, and those containing vinegar and salt as attracting agents. Many substances have been suggested as attractive baits without even giving them a trial. This confusion clearly shows that much work remains to be done along this line, especially in those regions east of the Mississippi river where, for some unknown reason, grasshoppers have been on the increase for several years.

During the summer of 1919 a serious outbreak of *Melanoplus femurrubrum* occurred at Lafayette, Indiana, thus furnishing an excellent oportunity for either increasing or clearing up some of this confusion. Accordingly, a series of experiments was planned with reference to the attractiveness of materials used in grasshopper baits, always keeping their availability and cheapness in mind.

By this plan the following points were to be determined.

1st. The comparative attracting power of various flavors.

2nd The relative attracting values of various syrups.

3rd. The attracting values of various body materials in poison bran mash.

To obtain accurate data on these points, the most promising of the various flavors, syrups and materials were selected from those which have been reported. It was necessary to place equal amounts of the mash, mixed in various ways, in the infested fields and record the number of hoppers attracted to them under natural field conditions.

The next problem was to make an accurate count of the hoppers attracted to these baits. In order to secure the count by ordinary ob-

servation it was necessary to approach so close to the bait that part of the hoppers were frightened away. Several types of traps were constructed, any of which would successfully retain the hoppers, once they had entered, thus making possible an accurate count. All of these were unsuccessful since the hoppers apparently preferred to observe the bait from the outside rather than enter the trap and feed.

Next, a few experiments were tried with a pair of army field glasses (Prism stereo 6 power) with which it was possible to make accurate counts with the observer stationed from twenty to thirty feet from the bait.. The grasshoppers seemed to have no objection to this method of procedure and it proved so satisfactory that all the data recorded in this paper were secured by the aid of these glasses.

All bait combinations were mixed in small batches, care being taken to add the various ingredients in their exact proportions. Equal amounts of the various baits were placed, each in the center of a heavy card-board disc, one foot in diameter and checked off in squares by heavy black lines to make the counts both easier and more accurate.

All hoppers observed feeding or within the six inch radius of the bait were included in each count, these counts being made at short intervals throughout the day. In order to eliminate any possible error due to greater abundance of grasshoppers in some locations, in all experiments the position of the cards was interchanged after every few counts. Thus the number of hoppers attracted to the various combinations of materials used in the baits was accurately determined. Most of the experiments were performed on a tract of uncultivated land covered with a rank growth of weeds and heavily infested with grasshoppers, *M. femur-rubrum* being by far the predominating species.

In the following experiments 16 flavors were used in 26 different combinations. The tables show the flavors which were run side by side on the same day, the number of counts made on each, and the total number of hoppers counted at each bait during the day. In these tables the word molasses is given for the common black strap molasses. The proportions in which the various flavors were used are as follows:- Black strap molasses, 2 quarts to 25 lbs. of bran. Fusel oil, anise oil and lemon extract, from 1 to 2 ounces to 25 lbs. of bran. Cider, vinegar, and grape juice, 1 quart to 25 lbs. of bran. Watermelon, cantelope, tomatoes and apple pomace, enough to make 1 quart to each 25 lbs. of bran.

TABLE I - EXPERIMENT 1938 RUN ON AUGUST 2, 1919 IN LIGHTLY INFESTED RAPE FIELD.

Flavor	Total No. counts during the day.	Total No. hoppers attracted during day.
Check (Wet bran)	50	7
Fusel oil & molasses	50	21
Apple & molasses	50	16
Anise oil & molasses	50	10
Lemon ext. & molasses	50	12
Totals	250	66

TABLE II - EXPERIMENT 1939 RUN ON AUGUST 4, 1919 AT EDGE OF WHEAT STUBBLE FIELD.

Flavor	Total No. counts during the day.	Total No. hoppers attracted during day.
Apple & molasses	33	97
Lemon ext. & molasses	33	107
Molasses & salt	33	47
Lemon peel & molasses	33	107
Molasses alone	33	131
Anise oil & molasses	33	79
Apple, salt & molasses	33	62
Orange peel & molasses	33	132
Check (wet bran)	33	178
Fusel oil & molasses	33	132
Watermelon & molasses	33	128
Totals	363	1200

TABLE III - EXPERIMENT 1940 RUN ON AUG. 5, 1919, ON INFESTED LAND GROWN TO WEEDS.

Flavor	Total No. counts during the day.	Total No. hoppers attracted during day.
Check (Wet bran)	13	66
Molasses alone	13	228
Watermelon alone	13	201
Watermelon & molasses	13	114
Apple alone	13	199
Apple & molasses	13	252
Anise oil alone	13	68
Anise oil & molasses	13	46
Orange peel alone	13	33
Orange peel & molasses	13	57
Lemon peel alone	13	82
Lemon peel & molasses	13	114
Fusel oil alone	13	41
Fusel oil & molasses	13	34
Totals	182	1535

TABLE IV - EXPERIMENT 1941 RUN ON AUG. 5, 1919, ON INFESTED LAND GROWN TO WEEDS

Flavor	Total No. counts during the day.	Total No. hoppers attracted during day.
Check (Wet bran)	13	345
Molasses alone	13	724
Watermelon alone	13	610
Watermelon & molasses	13	598
Apple alone	13	658
Apple & molasses	13	720
Anise oil alone	13	220
Anise oil & molasses	13	185
Orange peel alone	13	206
Orange peel & molasses	13	406
Lemon peel alone	13	371
Lemon peel & molasses	13	432
Fusel oil alone	13	320
Fusel oil & molasses	13	243
	182	6038

TABLE V - EXPERIMENT 1942 PERFORMED ON AUGUST 13,1919, ON INFESTED LAND GROWN TO WEEDS.

Flavor	Total No. counts during the day	Total No. hoppers attracted during day
Fusel oil & molasses	55	858
Orange pulp alone	55	883
Anise oil & molasses	55	804
Watermelon alone	55	690
Molasses alone	55	1113
Apple alone	55	950
Apple & mol asses	55	991
Watermelon & molasses	55	858
Anise oil & molasses	55	967
Lemon pulp & molasses	55	1052
Check (wet bran)	55	1041
Orange pulp & molasses	55	1054
Lemon pulp alone	55	1023
Fusel oil alone	55	947
Totals	770	13231

TABLE VI - EXPERIMENT 1960 PERFORMED ON AUGUST 13, 1919, ON INFESTED LAND GROWN TO WEEDS

Flavor	Total No. counts during the day	Total No. hoppers attracted during day
Cider & molasses	50	328
Tomatoes & molasses	50	225
Lemon pulp & molasses	50	294
Anise oil & molasses	50	262
Check (wet bran)	50	304
Vinegar & molasses	50	417
Cantelope & molasses	50	400
Lemon peel & molasses	50	343
Fusel oil & molasses		282
Apple pomice & molasses	50	260
Apple & molasses	50	340
Lemon ext. & molasses	80	238
Grape juice & molasses	50	225
Orange peel & molasses	50	216
Molasses alone	50	292
Totals	750	4426

In the experiments shown in the preceding tables, a total of 26,496 hoppers were recorded in 2497 separate counts. With data on this large number of individuals, certainly fairly accurate conclusions can be drawn. The totals for these six experiments show that of these 26 flavor combinations used, black strap molasses without additional flavor attracted more hoppers than any other, apple and black strap molasses being second, and the check (wet bran) third.

The advantage of using the well known citrus fruit flavors is not borne out here as in every case those combinations containing citrus fruits were well down the list when taken in the order of the total number of hoppers attracted in the six experiments, even the check (wet bran alone) giving a much better total than any of these. Since the check ran so high in the list, one might well think that there is nothing gained by the use of any kind of flavors or syrups in poison

bran mash for grasshoppers. The data show that the check total was 1941 hoppers while the black strap molasses totaled 2488, being 547 or slightly over 28% more than the check. Certainly one could well afford to add black strap molasses at the rate of 2 quarts per each 25 pounds of bran to obtain a 28% increase in attractiveness

In experiment 1960 (Table VI) it is seen that vinegar and black strap molasses lead the list with 417 hoppers, cantelope and black strap being second with 400. Due to lack of time these two combinations were run but once and showed up favorably. As soon as opportunity affords further experimentation will be performed on these flavors.

Next it was decided to determine whether or not the use of salt in bran mash adds to its power to attract grasshoppers. Accordingly an experiment was devised whereby four flavor combinations with and without salt (enough to taste strongly) were run side by side as were the experiments shown above. The following table shows the flavors used, the total number of counts made, and the total number of grasshoppers attracted to each.

TABLE VII - EXPERIMENT 1942, PERFORMED ON AUGUST 7, 1919 OF INFESTED LAND GROWN TO WEEDS.

Flavor	Total number of counts	Total number hoppers attracted Without salt,	With salt
Lemon ext. & molasses	25	343	
Lemon ect., molasses & salt.	25		213
Lemon peel, & molasses	25	436	
Lemon peel, molasses & salt	25		276
Apple & molasses	25	297	
Apple, molasses & salt	25		261
Molass alone	25	343	
Molasses & salt	25		339
Totals	200	1419	1089

The above table shows that a total of 3508 hoppers were recorded in 200 separate counts. In every case the combinations without salt attracted a greater number of hoppers, the total being over 23% more. This would indicate that no benefits are derived from the use of salt in bran mash for grasshoppers, in fact here it apparently repels rather than attracts them.

SYRUP EXPERIMENTS

Having come to a definite conclusion concerning the attractiveness of flavors in bran mash, next it was decided to make observations on the attractive powers of various syrups. Several of the more common syrups were secured and used in the mixing of small amounts of bait

at the rate of 2 quarts to each 25 pounds of wheat bran. The mixtures were placed on cards in an infested field and run similar to the experiments explained above. The following table shows the syrups used, the total number of counts made, and the total number of hoppers attracted to each.

TABLE VIII - EXPERIMENT 1968 PERFORMED ON AUGUST 26, 1919 ON INFESTED LAND GROWN TO WEEDS.

Syrup	Total counts made.	Total number hoppers attracted.
Black Strap Molasses	60	831
Dark Karo Corn Syrup	60	490
Light Karo Corn Syrup	60	510
Sorghum	60	476
New Orleans Molasses	60	439
Check (wet bran)	60	435
Totals	360	3181

The syrups were run in duplicate, 30 counts being made from each, the combined results of which are shown in the above table. These data show that black strap molasses attracted by far more hoppers than any of the other syrups, which were very little better than the check (wet bran).

EXPERIMENTS ON BODY MATERIALS

The recent advance in the price of wheat bran has made its use in grasshopper baits almost prohibitive in certain localities. Not only this but it has been impossible to secure wheat bran at any price in certain regions. Accordingly an experiment was planned whereby various body materials were run side by side, as shown in the above experiments and records made of the number of hoppers attracted to each. In all of these combinations black strap molasses was used at the rate of 2 quarts to each 25 pounds of body material.

TABLE IX - EXPERIMENT 1946, PERFORMED ON AUGUST 11, 1919 ON INFESTED LAND GROWN TO WEEDS.

Body Material	Total number counts	Total number hoppers attracted.
Hickory sawdust	48	1571
Hickory sawdust & bran 50-50	48	2891
Red gum sawdust	48	1975
Red gum sawdust & bran 50-50	48	2297
Hardwood sawdust	48	1430
Hardwood sawdust & bran 50-50	48	2201
Soft pine sawdust	48	1303
Soft pine sawdust & bran 50-50	48	2046
Horse manure	48	1214
Bran alone	48	2522
Totals	480	19,040

This table shows that in every case sawdust and wheat bran mixed in equal parts attracted more grasshoppers than did the sawdust alone. The hoppers attracted to the four mixtures containing only sawdust totaled 6459 while those counted from the four containing 50% bran, totaled 8845, which shows an increase in attractiveness of 36.9% due to the use of 50% bran. The mixture containing bran alone headed the list with 2522 hoppers but this was only 311 or 14% more than the average of the four mixtures containing bran and sawdust in equal portions. The bait made from horse manure fell far below any of the rest, showing that its attractive power for grasshoppers is comparatively low.

Table X shows the conditions of temperature and humidity for the days on which the preceding experiments were run.

TABLE X - TEMPERATURE AND HUMIDITY RECORDS. LAFAYETTE, INDIANA.

Date 1919	6 A.M. T. H.	8 A.M. T. H.	10 A.M. T. H.	12M. T. H.	2 P.M. T. H.	4 P.M. T. H.	6 P.M. T. H.	Min. T. H.	Max. T. H.	Mean T. H.
Aug. 2	56 89	60 87	70 50	76 42	77 42	78 40	78 42	56 40	78 90	71 56
Aug. 4	71 71	73 79	76 75	90 60	94 47	97 40	95 42	71 40	97 79	85 59
Aug. 5	75 88	78 84	80 78	74 95	79 83	78 80	81 68	81 68	75 95	77 82
Aug. 7	69 94	72 84	75 70	81 65	87 50	88 46	87 44	69 44	88 94	80 65
Aug. 11	55 89	55 89	66 60	79 44	82 39	82 36	78 39	82 36	55 89	71 56
Aug. 13	68 66	65 94	67 98	75 77	78 64	82 62	80 75	65 62	82 98	73 76
Aug. 26	50 99	51 100	68 52	75 41	76 41	76 40	76 40	50 40	76 100	66 59

T = Temperature
H = Humidity

CONCLUSION

The data herein reported indicate the following:-

1. Fruit flavors in bran mash when used against *M. femur-rubrum* under Indiana conditions, at least, apparently are not necessary.
2. Black strap molasses was found to be the best of the flavor combinations used.
3. Salt does not add to the attractiveness of poison bran mash.
4. Black strap molasses was better than any of the syrups herein tested, all others being only slightly better than wet bran alone.
5. Sawdust and bran used in equal parts as a body material for mash attracted 36.9% more hoppers than sawdust alone.
6. Sawdust and bran used in equal parts as a body material for bran mash attracts nearly as many hoppers as wheat bran alone.

SOME FACTORS INFLUENCING THE EFFICIENCY OF GRASSHOPPER BAITS[1]

By A. L. FORD and W. H. LARRIMER, *Scientific Assistants, Bureau of Entomology, West LaFayette, Indiana*

Important considerations in grasshopper control have always been, the best poison to use, the proper strength at which to include it in the bait, and the rate of application of the mixture over the infested area in order to obtain a maximum kill. In order to obtain information on these points a series of experiments were conducted during the summer of 1919 at Lafayette, Indiana in fields infested with grasshoppers, of which at least 99% were *Melanoplus femur-rubrum*. Preliminary to this work the maximum daily feeding period was found to be from 8:30 A.M. until 12:30 P.M. (Daylight saving time). It was also necessary to determine which syrup would prove most attractive to grasshoppers. The experiments as here reported can be grouped according to the following outline:-

1st. To determine the comparative efficiency of various syrups when used under field conditions.

2nd. To determine the optimum strengths of various arsenicals in bran mash.

3rd. To determine the optimum rate of application per acre for poison bran mash.

4th. Having found the optimum strengths and rates of application for the various arsenicals, to determine which of them is most efficient when used under its optimum conditions.

METHOD OF OBTAINING PERCENTAGE OF KILL

In estimating the percentage of grasshoppers killed by poison bran mash, practically all workers on this subject have merely counted the number of dead hoppers per unit area of ground and estimated the number of living hoppers remaining. The writers believe that this is not an accurate method for two reasons. 1st. It is impossible to even estimate accurately the number of living grasshoppers per unit area because of the unusual activeness of this group of insects. 2nd. To count the number of poisoned hoppers per unit area is inaccurate since not only many hoppers enter cracks in the soil or seek low shady places to die, but other insects and birds consume or carry away many of them before a count can be made.

[1]Published by permission of the Secretary of Agriculture.

The following method was devised with the idea of making the observations more accurate. Quarter acre plots in an infested alfalfa field were treated with the poison mash, care being taken to keep each plot well isolated from the others to avoid error due to the hoppers migrating from one plot to another. After allowing the hoppers to feed on the poison mash in the field for several hours, but not long enough for any of them to succumb to its effects, sweepings were made with hand nets from the poisoned plots. In all of the following experiments the poison bran mash was applied to the infested plots between 8 A.M. and 9 A.M. and the sweepings made between 2 and 3 P.M. of the same date. The hoppers thus swept were placed in bags and brought to the laboratory where they were put in out of door screen cages with green corn suckers for food. In each case a lot of hoppers were swept from an unpoisoned area and run as a check. The cages were examined daily and the dead hoppers removed and recorded. At the end of six days the experiment was closed and the number of living hoppers remaining in each cage recorded. Thus the number of hoppers killed by each application of poison mash and the number of hoppers surviving was accurately determined.

Syrup Experiments

A series of experiments was planned whereby the percentage of kill due to the various syrups was determined. Small amounts of poison mash were mixed with Paris green at the rate of one pound per each 25 lbs. of bran and the various syrups as shown in the following table. Quarter acre plots were treated with these various mixtures as described above, and the hoppers handled as previously explained. This experiment was run in duplicate, the following table showing the combined results of these two series.

TABLE I (Poison mash applied Aug. 28).

Syrup	Total No. hoppers swept	No. dead hoppers removed	No. living hoppers remaining	Percentage of kill.
Black strap 2 qts. per 25 lbs. bran	107	97	10	90.6
Black strap 1 qt. per 25 lbs.	213	192	21	90.1
Dark Karo 2 qts. per 25 lbs.	188	126	62	67.0
Dark Karo 1 qt. per 25 lbs.	196	129	67	65.8
Light Karo 2 qts. per 25 lbs.	196	145	51	73.9
Light Karo 1 qt. per 25 lbs.	227	168	59	74.0
Sorghum 2 qts. per 25 lbs.	131	85	46	65.1
Sorghum 1 qt. per 25 lbs.	175	106	69	60.5
Orleans molasses 2 qts. per 25 lbs.	220	156	64	70.9
Orleans molasses 1 qt. per 25 lbs.	220	183	37	83.1
Wet bran alone	284	234	50	82.4
Check (Unpoisoned)	178	11	167	6.1
Totals	2335	1632	703	

The mixtures containing black strap molasses were noticeably better than the rest, both of these giving better than 90% kill, there being little difference between the two quart and one quart strengths. All of the other syrups except Orleans molasses at the one quart strength were even poorer than the mixture without any syrup. The check (unpoisoned) showed a mortality of 6.1% during the six days of confinement.

Optimum Strength of Arsenicals

Having determined (to the writers' satisfaction) the best time to apply poison bran mash in the field and the proper syrup to obtain the maximum results, experimental work was started on the various arsenicals used in bran mash. In all of the following experiments black strap molasses was used without fruit flavors, these having been found unnecessary by another series of experiments.

First it was decided to determine, if possible, the most efficient strength of arsenicals in poison bran mash, basing this both on percentage of kill and cost to the farmer. A series of experiments was arranged whereby the common arsenicals namely, Paris green, white arsenic (As_2O_3) and crude arsenic (crude arsenious oxide) were used at varying strengths, as shown in the following tables. The mash was applied and the resulting percentages of kill obtained by the method previously explained. Each series of experiments was performed in duplicate, the following tables giving the combined results. These tables show the poison used, its strength, the total number of hoppers swept, hoppers which died, hoppers remaining alive, and the resulting percentages of kill.

Table II (Bait applied Aug. 21).

Strength of Paris green	Total No. hoppers swept	No. hoppers dying	Hoppers remaining alive	Percentage of kill.
¼ lb. per 25 lbs. bran	158	115	43	72.7
½ lb. per 25 lbs. bran	172	136	36	79.0
¾ lbs. per 25 lbs. bran	188	138	50	73.4
1 lb. per 25 lbs. bran	136	115	21	84.5
1¼ lb. per 25 lbs. bran	236	142	94	60.1
1½ lb. per 25 lbs. bran	259	173	86	66.8
Check (Unpoisoned)	160	18	142	11.2
Totals	1309	837	472	

Apparently the higher strengths of Paris green do not give as good results as the lower ones. The one pound formula gave the best kill, being 84.5%, but the ½ lb. strength gave 79% kill, there being only 5½% difference. It would appear that the ½ lb. strength is probably more efficient than the 1 pound, since a 5½% increase in kill would not warrant doubling the amount of Paris green at its present price.

TABLE III WHITE ARSENIC (Bait applied Aug. 22).

Strength of White Arsenic	Total No. hoppers swept	No. of hoppers dying	No. hoppers remaining alive	Percentage of kill.
¼ lb. per 25 lbs. bran	191	78	113	40.8
½ lb. per 25 lbs. bran	145	113	32	77.9
¾ lb. per 25 lbs. bran	154	140	14	90.9
1 lb. per 25 lbs. bran	201	169	32	84.0
1¼ lb. per 25 lbs. bran	141	107	34	75.8
1½ lb. per 25 lbs. bran	197	161	36	81.7
1¾ lb. per 25 lbs. bran	151	107	44	70.8
2 lbs. per 25 lbs. bran	170	136	34	80.0
2¼ lbs. per 25 lbs. bran	174	129	45	74.1
2½ lbs. per 25 lbs. bran	166	145	21	87.3
Check (unpoisoned)	154	9	145	5.8
Totals	1844	1294	550	

The results of these experiments show the usual formulae which contain white arsenic as the poisoning element are stronger than necessary. Here ¾ lbs. per 25 lbs. of bran gave the best kill, it being even better than any of the higher strengths. The check hoppers showed a 5.8% mortality during the six days of captivity.

TABLE IV CRUDE ARSENIC (Bait applied Aug. 27).

Strength of crude arsenic	Total No. hoppers swept	No. hoppers dying	No. hoppers remaining alive	Percentage of kill.
¼ lb. per 25 lbs. bran	211	114	97	54.0
½ lb. per 25 lbs. bran	283	149	134	52.6
¾ lb. per 25 lbs. bran	29	209	87	70.6
1 lb. per 25 lbs. bran	234	155	79	66.2
1¼ lb. per 25 lbs. bran	245	177	68	72.2
1½ lbs. per 25 lbs. bran	181	138	43	76.2
1¾ lbs. per 25 lbs. bran	186	144	42	77.4
2 lbs. per 25 lbs. bran	201	141	60	70.1
2¼ lbs. per 25 lbs. bran	116	72	44	62.0
2½ lbs. per 25 lbs. bran	186	138	48	74.2
Check (Unpoisoned)	242	12	230	4.9
Totals	2381	1449	932	

From this table we find that 1¾ lb. rate gave the best kill but the 1½ lb. rate was only 1.2% below it. Because of this the 1½ lb. strength might well be recommended when crude arsenic is used in grasshopper baits, although satisfactory results were obtained from all strengths above and including ¾ lb. Only 4.9% of the check hoppers died during the six day period in captivity.

Rate of Application

In determining the rate to apply poison bran mash to obtain the best results, a series of experiments was planned whereby poison bran mash was mixed with the various arsenicals at their optimum strengths as determined above. Data were obtained by the method previously described. Each series of experiments was run in duplicate, the combined results of which are shown in the following tables.

Table V 'Paris Green (Bait applied Sept. 21.).

Rate of application (wet weight)	Total No. hoppers swept	No. hoppers dying	No. hoppers remaining alive	Percentage of kill.
5 lbs. per acre	149	81	68	54.3
7½ lbs. per acre	186	115	71	61.8
10 lbs. per acre	187	118	69	63.1
12½ lbs. per acre	163	103	60	63.1
15 lbs. per acre	192	149	43	77.6
17½ lbs. per acre	197	141	56	71.5
20 lbs. per acre	203	146	57	71.9
Totals	1277	853	424	

It will be seen that the 15 lbs. rate gave noticeably better results than any of the rest. The lower rates gave comparatively poor kills in every case.

In sweeping hoppers for the check cage in this series of experiments a number of poisoned hoppers were included, due to some slight confusion existing in the fields in which the experiments were conducted. this also occurred in the experiments, the results of which are shown in Table VI. Because of this the checks were omitted from these two series of experiments.

Table VI White Arsenic (Poison mash applied Sept. 3).

Rate of application (wet weight)	Total No. hoppers swept	No. hoppers dying	No. hoppers remaining alive	Percentage of kill.
5 lbs. per acre	167	132	35	79
7½ lbs. per acre	159	152	7	95.6
10 lbs. per acre	124	119	5	95.9
12½ lbs. per acre	136	115	21	84.5
15 lbs. per acre	94	82	12	87.2
17½ lbs. per acre	104	84	20	80.7
20 lbs. per acre.	115	104	11	90.4
Totals	899	788	111	

TABLE VII CRUDE ARSENIC (Bait applied Sept. 24).

Rate of application (wet weight)	Total No. hoppers swept	No. hoppers dying	No. hoppers remaining alive	Percentage of kill.
5 lbs. per acre	171	145	26	84.8
7½ lbs. per acre	188	168	20	89.3
10 lbs. per acre	177	152	25	85.8
12½ lbs. per acre	179	147	32	82.1
15 lbs. per acre	179	140	39	78.2
17½ lbs. per acre	189	144	45	76.2
20 lbs. per acre	186	152	34	81.7
Check (unpoisoned)	372	44	328	11.8
Totals	1641	1092	549	

In this case 7½ lbs. and 10 lb. rates gave almost perfect kills, both being noticeably better than the others, although excellent kills were obtained from all the various rates of sowing.

From these data it will be seen that the 7½ lb. and 10 lb. rates gave the best kill; even the 5 lb. rate gave excellent results. The check showed a 11.8% mortality during the six days in captivity.

The following table shows a summary of the three series of experiments shown in tables V, VI and VII.

TABLE VIII

Rate of application	Total No. hoppers swept	No. hoppers dying	No. hoppers remaining alive	Percentage of kill.
5 lbs. per acre	487	358	129	73.5
7½ lbs. per acre	533	435	98	81.6
10 lbs. per acre	488	389	99	79.7
12½ lbs. per acre	478	365	113	76.3
15 lbs. per acre	465	371	94	79.7
17½ lbs. per acre	490	369	121	75.3
20 lbs. per acre	504	402	102	79.7
Check (Unpoisoned)	372	44	328	11.8
Totals	3817	2733	1084	

Consulting the above table we find that very little difference exists in the percentage of kill obtained from applying poison bran mash at different rates per acre. The 5 lb. rate fell somewhat below the rest, apparently being a little too thin. The 7½ lb. rate gave slightly the best results although little better than the higher rates. From the results here obtained a general recommendation to apply bran mash

at the rate of from 5 to 10 lbs. per acre might well be made. This is about as thinly as the average person can apply it by hand and cover the ground uniformly,

Comparative Value of Poisons

The optimum strength of the various arsenicals in poison bran mash and the optimum rate of application in the field, having been determined to the writers' satisfaction, it was decided to learn, if possible which arsenical is most effective in grasshopper control. Accordingly a series of experiments were outlined whereby the three common arsenicals, namely Paris green, white arsenic and crude arsenic, were run under similar conditions and in each case at their optimum strength and rate. Quarter acre plots were treated with the various mixtures and the hoppers swept therefrom handled as has been previously explained.

The following table which includes the results of 8 series of experiments in which the three arsenicals were run, shows the date, poison, number of hoppers swept, number of hoppers which died, the number of hoppers remaining alive, and the percentage of kill.

Table IX

Date	Poison	Total No. hoppers swept	No. hoppers dying	No. hoppers remaining alive	Percentage of kill
Aug. 18	Paris green	90	52	38	57.7
	White arsenic	39	23	16	58.9
	Crude arsenic	52	30	22	57.6
Aug. 18	Paris green	96	73	23	76.0
	White arsenic	65	36	29	55.4
	Crude arsenic	63	45	18	71.4
	Check (Unpoisoned)	155	8	147	5.1
Sept. 8	Paris green	36	24	12	66.6
	White arsenic	49	26	23	53.0
	Crude arsenic	44	26	18	59.1
Sept. 8	Paris green	42	21	21	50.0
	White arsenic	50	29	21	58.0
	Crude arsenic	54	30	24	55.5
Sept. 8	Paris green	43	28	15	65.1
	White arsenic	42	30	12	71.4
	Crude arsenic	42	22	20	52-4
Sept. 8	Paris green	39	21	18	53.8
	White arsenic	54	35	19	64.8
	Crude arsenic	50	34	16	68.0
	Check	126	16	110	12.2
Sept. 12	Paris green	60	49	11	81.6
	White arsenic	66	45	21	68.2
	Crude arsenic	57	43	14	75.4
Sept. 12	Paris green	54	41	13	75.9
	White arsenic	61	47	14	77.0
	Crude arsenic	58	39	19	67.2
	Check	128	14	114	10.9
	Totals	1715	887	828	

This series of experiments shows the variation in kill received from the different poisons for the several dates on which the poison was applied. In order to come to a definite conclusion it is necessary to combine all tests on each poison under one head. This is shown in the following table.

TABLE X

Poison	Total No. hoppers swept	No. hoppers dying	No. hoppers remaining alive	Percentage of kill.
Paris green	460	309	151	67.1
White arsenic	426	271	155	63.6
Crude arsenic	420	269	151	64.0
Check ..	409	38	371	9.2
Totals	1715	887	828	

When Paris green, white arsenic, or crude arsenic are used at their optimum strengths and applied at the optimum rates, it would seem that one is practically as good as the other. In these eight series of experiments there was only 3.5% variation in the percentage of kill. Although rather poor kills were obtained in the experiments shown in Table IX, due to lateness of the season, the comparative results are fairly accurate since all poisons were applied under similar conditions.

SUMMARY

1. Black strap molasses gave much better results than any of the other syrups used.
2. The optimum strengths for the three standard poisons was found to be, Paris green ½ lb., white arsenic ¾ lb., and crude arsenic 1½ lb. per each 25 lbs. of bran.
3. The optimum rate of applying poison bait was found to be 7½ lbs. of the wet mash per acre, however, a general recommendation of from 5 to 10 lbs per acre might well be made.
4. There was very little difference in the three arsenicals when run under similar conditions at their optimum strengths and rates.

OBSERVATIONS ON THE FALL ARMY WORM (*LAPHYGMA FRUGIPERDA* Smith & Abbott) AND SOME CONTROL EXPERIMENTS[1]

By ROGER C. SMITH, *Assistant Entomologist, Kansas State Agricultural Experiment Station*

Early in September 1920, larvae of the fall army worm suddenly appeared in large numbers in various localities in the central and east central parts of this state. Inquiries began to come in on September 9th and by the 12th their injury to alfalfa was quite apparent at Manhattan. The outbreak was not general, but scattered and confined to occasional fields.

There were three primary areas of infestation in the state. First, the largest one, in south central Kansas, comprising Barber, Harper, Sumner, Cowley, Chautauqua, Kingman, Sedgwick, and Reno Counties. The second was that about Manhattan, comprising the counties of Riley, Clay, Geary, Pottawatomie, and the northern part of Morris County. The third comprised Anderson and Coffey Counties. The larvae were first seen defoliating volunteer wheat and oats, then upon young alfalfa which had been sown after harvest, and finally defoliating alfalfa which was not quite ready for the fourth cutting. Correspondents reported that entire fields of volunteer wheat as large as 140 acres were eaten bare by the larvae. In all alfalfa fields seen, the damage was localized in the field. There were several fields of alfalfa on the college farm severely attacked, and it was in these fields that most of the observations herein reported were made.

The history of former outbreaks has been well given by Chittenden (1901)[2] and Hinds and Dew (1915).[3] In this state this insect is not an annual pest, the last outbreak occurring in the fall of 1911. From the records of this station, it has apparently not since occurred in numbers until this fall.

The nature of the recent outbreak, and the conditions leading up to it, were typical, judging from the published accounts. Last win-

[1]Contribution No. 64 from the Entomological Laboratory, Kansas State Agricultural College. This paper embodies some of the results obtained in the prosecution of project No. 115 of the Kansas Experiment Station.

[2]Chittenden, F. H., 1901. Fall Army Worm and Variegated Cutworm. Bul. 29, N. S. Div. of Ent. U. S. Dept. Agr. pp. 13-45.

[3]Hinds, W. E., and Dew, J. A., 1915. The Grass Worms or Fall Army Worms. Alabama State Agr. Exp. Sta. Bul. 186, pp. 59-92.

ter was unusually dry and the rainfall in the spring somewhat below normal. There was little rain until after harvest, when the precipitation during the month of August was unusually heavy. As a result of this, there was much volunteer wheat and oats over the state and in newly sown alfalfa fields which followed wheat. There was also a heavy growth of crab grass, foxtail, and similar grasses. Alfalfa likewise made a heavier growth than had either of the two previous cuttings.

In all infested fields seen, the larvae began their destructive work in a small spot, and then worked outward over a fanshaped area, or, under certain conditions, in all directions. In some fields, the volunteer wheat around a straw stack was their starting point. At the college, the larvae appeared at one side of the fields, generally at one of the lowest spots. As food became scarce they spread out over the field, leaving the alfalfa and grasses in the fields completely defoliated.

The larvae fed first on the young leaves at the crown of the alfalfa plants, then climbed up the plant, defoliating as they went, and devouring the uppermost leaves last. They climbed up the plants and began feeding about three o'clock on clear days, while in the morning there were only a few larvae upon the plants. During the day, most of the larvae rested at the crown of the plant, under the dried leaves or other trash, under clods or the loose earth. When the plants were jarred, as when one walked through the field, or when bran mash struck the plants, the larvae dropped to the ground. They generally dropped also when attacked by the Tachinid flies, probably as a protective measure, but the flies usually followed and often deposited their eggs on them. Their work was evident first where the alfalfa was thinnest on the ground Since there was less food in such places per unit of area, their migration was most rapid here. This explained, to some extent at least, the peculiar contour of the defoliated areas in some of the fields.

The larvae disappeared almost as suddenly as they came. By the twenty-third of the month, practically all larvae were full grown, and they were very scarce on the twenty-fifth. Larvae collected when the outbreak was first noticed were all prepupae or pupae on the twenty-fifth. In two days more there was only an occasional larva to be found.

The first adults appeared in rearings on September 30th. By October 7th, about half of the reared pupae had yielded adults. It was concluded that the maximum emergence of moths in the field occurred on this date. They appeared to be about as numerous as the larvae

had previously been. When disturbed they flew a short distance with the wind and nervously sought shelter in some clump of alfalfa or grass. Many had one or more of their wings crumpled, caused probably from emerging through the hard soil. Moths from reared larvae were mated in laboratory cages, and on October 9th several egg masses were obtained from moths which emerged October 3rd. From this time on, egg masses were obtained nightly until October 22nd. A careful search was made almost daily for egg masses in the field, but only one was found. It was found October 18th on the under side of a leaf of a young oak tree in a small patch of alfalfa. The eggs were fertile and hatched on October 20th. One larva was taken by sweeping during the month of October. It was surprising that so few eggs and larvae were found after such a large emergence of moths. Both collected and newly emerged moths from rearings failed to deposit eggs in out door field cages. The batches deposited in confinement all hatched, the fertilty as shown by two large batches apparently typical being 84 per cent. The interval between oviposition and hatching in indoor laboratory rearings was from three to four days.

Some of the larvae hatching in the laboratory were placed on alfalfa in out door cages to see if another generation could be reared. They fed to some extent but the heavy frosts the latter part of October probably killed them. At least on November 20th, it was concluded that all larvae in the four cages were dead, thereby apparently eliminating the possibility that they might over-winter as partly grown larvae.

On several occasions, small plats in areas where larvae had been most abundant were dug up in search of live pupae overwintering. None were found, but many empty pupal cases were seen. They were located from about three inches below to just beneath the surface. The very hard soil apparently prevented many from going to the greater depth. Dipterous larvae, probably parasitic, were found during the digging, overwintering as larvae. An effort is being made to carry living pupae through the winter, but the general concensus of opinion, however, appears to be that they do not ordinarily winter successfully as pupae in this latitude, but that the moths migrate northward from the south in the spring.

Sowing poisoned bran mash as in the control of the true army worm has been recommended for the control of this insect. During the short period this outbreak was in progress, it was decided to test the efficiency of the well known Kansas bran mash as a control measure and to compare with it certain modifications of the regular formula. Recent work with the substitution of sawdust for bran with other insects

suggested a trial with this one. Table I gives a list of the plats sown and the percent of control obtained based on counts of living and dead larvae. Conditions in the alfalfa fields where these plats were located were very similar if not identical. Death of larvae, due to natural causes, averaged 3.2 per cent in these plats. The percentages in the table were computed on the total counts of three individuals, the writer having been one of them.

TABLE I - EXPERIMENTS AND PERCENT OF CONTROL OBTAINED

Plat No.	Pcison used	Saw-Dust Pounds	Bran Pounds	Molasses Pints	Lemons	Water Approx. Gallon	Date Sown	Percent of larvae dead 24 hrs.	48 hrs.
1	¼ lb. Paris green	5	0	1	0	1	9-16	51.5	35.3
2	½ lb. Pow'd. Ar. of Lead	5	0	1	1	1	9-16	10.0	8.2
3	¼ lb. Paris green	0	5	1	1	1	9-14	81.3	93.5
4	Arsenic[1] in citrus pulp	0	5	0	0	1	9-16	19.6	15.6
5	¼ lb. Paris green	5	0	1	1	⅞	9-17	21.7	20.8
6	¼ lb. Paris green	0	5	1	0	⅞	9-17	86.6	92.4
7	¼ lb. Paris green	0	5	1	2	⅞	9-20	88.0	97.1
8	Arsenic in citrus pulp	0	5	0	0	1	9-20	2.9	15.7
9	¼ lb. Paris green[2]	0	5	1	0	¼	9-20	99.6	99.5
10	1 lb. Paris green	0	20	4	3	3½	9-18		92.1
11	Check Plat	0	0	0	0	0	9-18	3.2	

[1]A commercial preparation, made by the Exchange Orange Products Co. One-fifth of a can was used.
[2]Larvae were rapidly entering ground for pupation at this time.

The regular bran mash mixture made with Paris green gave excellent results. It is interesting to note that this mixture gave approximately the same results where the lemons were used according to the formula, where omitted, and where the number was doubled. It was observed that dead larvae were more often found where bran mash particles could be seen on the ground. A lower percent of control was obtained on the plats where sawdust was substituted for bran. The sawdust mixtures were distinctly less palatable to the larvae. It was a common occurrence to see larvae crawl over these mixtures without feeding, but in the case of the regular bran mash, they fed much more freely. The sawdust, however, was not above criticism. It was obtained at the college carpenter shop and consisted of a variety of kinds, pine probably predominating. In addition to the probable repellent odor of pine, some of it was somewhat coarser than desired.[3]

[3]Davis, J. J., and Turner, C. F., 1918. Experiments with Cutworm Baits. Canadian Ent., 50:187-192.

The only experiments with white arsenic were the two plats sown with a commercial citrus fruit pulp mixture (Mackie, 1920),[4] diluted with bran, but a poor killing was made in both cases. In fairness, it should be stated that this preparation is recommended by the manufacturers as a grasshopper poison. While the results on these two plats were almost identical, they are not regarded by the writer as conclusive. Perhaps the conclusions of Davis and Turner (loc.cit.) to the effect that white arsenic was less effective than Paris green with the true army worm are evidenced here in these results with this insect.

Some confusion developed during this outbreak over the terms "white arsenic" and "lead arsenate", or "arsenate of lead." In several instances arsenate of lead was sold instead of arsenic, and was mixed in the bran mash at the proportions prescribed for arsenic. Two sowings of this mixture failed to check the larvae appreciably. In one instance, paste arsenate of lead was sold a farmer in place of arsenic without explaining the substitution. Paris green has an advantage of not being readily mistaken for other substances, and in the mixing shows up well on the bran flakes.

Parasitic Tachinid adults were plentiful at all times during this outbreak, but the percentage of larvae with the ivory white eggs on their bodies varied greatly between fields. In one field, early in September, a parasitism of about 95 per cent was found. On the college farm, at the same time, the parasitism was four per cent, but later increased to about 50 per cent. *Winthemia quadripustulata* Fabr., was the more common Tachinid in the fields. About 80 adults of *Muscina stabulans* Fall. emerged from 100 fall army worm larvae collected in the field and placed in a jar for rearing parasite adults. Dr. Aldrich states with the determination of the specimens that "the larvae according to Keilin is saprophagous until near the end of the second stage, then becoming predaceous on other dipterous larvae. It is not a parasite, but the fly lays its eggs where there are other dipterous larvae." It is believed that relatively few larvae bearing Tachinid eggs upon their bodies died as a result of the parasitic larvae. It is well known that if the host molts before the parasite egg hatches, the egg is discarded with the molt. It is doubtful if the larva into which the parasitic larva has entered takes any food thereafter.

It was found that when larvae bearing eggs of Tachinidae upon their bodies are killed by poisoned bran mash that the parasites did not develop. There were no exceptions in a batch of 100 larvae, i.e., no para-

[4]Mackie, D. B., 1920. A Prepared Grasshopper Poison. Monthly Bul. Dept. Agri. Cal. IX, No. 5-6, pp. 194-197.

site adults developed from the lot. It was further found that larvae are rarely if at all poisoned by feeding upon a larva which has died from eating poisoned bran mash. In a series of 77 larvae, of which five ate all of a dead larva and died; 29 ate all and lived. The increase in the death rate over the check was 1.7 per cent, an increase so small that it might be otherwise explained.

Summary

An outbreak of the fall army worm occurred in central and east central Kansas in September, 1920. Only occasional fields were attacked and frequently only parts of these were defoliated. The larvae were first seen defoliating volunteer wheat and oats, but soon appeared in alfalfa fields where the real damage was done. The moths emerged in the field early in October, but very few eggs were deposited. Control experiments with the poisoned bran mash made with Paris green gave satisfactory results. Sawdust substituted for the bran was less attractive to the larvae, and a lesser killing was made.

Scientific Notes

Harlequin cabbage bug in South Dakota. The Harlequin cabbage bug (*Murgantia histrionica* Hahn) has established itself in South Dakota and has already proven to be a serious pest in its new home. Our attention was called to this pest for the first time in 1919. During this year complaints regarding the injurious work of this bug came to us chiefly from the lower central portion of South Dakota. In 1920 the injury was much more serious and extended thru central South Dakota, from the southern border almost to the northern. Cruciferous plants were most generally injured, but potatoes, tomatoes, beans, beets, squash, pumpkin, corn, plum trees and even cottonwoods were reported to have suffered.

H. C. Severin,
State Entomologist, Brookings, S. D.

Peach Seedlings Attacked by Dipterous Larvae. On March 14, 1921 some peach seedlings infested with dipterous larvae and puparia were received from H. N. Shamburger Nursery Company, Myrtle Springs, Van Zandt County, Texas. This material was placed in a rearing cage and the first adult flies appeared on March 22. The flies were identified by Dr. Aldrich as *Hylemyia cilicrura* Rd. (*Phorbia fusciceps*, Zett of authors). Dr. Howard states that this species is supposed to be identical with the seed corn maggot (*Anthomyia zeae*, Riley).

The following extracts relative to the injury are taken from a letter received April 6, 1921, from the proprietor of the Nursery:

"We first notice that the plant looks sick, it ceases growing, gradually turns pale yellow in color and finally withers up and dies. About 25% of all our seedlings at one time seemed to be affected, however, not all of these have died yet."**

"This is the first time we ever had trouble with this pest. It is entirely new to us."

"**Nothing else in our Nursery is affected."

"We have examined hundreds of seedlings and these maggots have been found in the seed only, none feeding on the stem."

"***A small quantity of seed from the same pit, planted about 15 days earlier than the main crop on the land adjoining, and not more than 1% of these were affected.***"

No further reports of any additional infestations have been received.

H. J. Reinhard,
College Station, Texas

The Stanford Collection of Coccidae. The already extensive collection of Coccidae in the Department of Entomology at Stanford University, has received some very important additions during the past year. Mr. A. H. Hollinger has generously given to the department his collection of Coccidae from Texas, consisting of approximately 1000 lots. The work that has been done on this collection shows that it contains many interesting and important species.

Mr. O. E. Bremner, County Horticultural Commissioner for Sonoma County, and Mr. R. S. Woglum for many years connected with the Bureau of Entomology, now Entomologist for the California Fruit Growers Exchange, have both loaned their extensive collections of Coccidae to our Department in order that they may become available for study by specialists in this group. These collections represent the results of many years work and they are especially valuable because they contain so many species from various parts of the world. The Bremner collection is of particular interest from the presence in it of type material of numerous species described by Maskell and Cockerell.

These, with the collections recently made by Mr. Ferris in Lower California and the Southwestern United States, and the material that has been received by exchange from foreign coccidologists, make the Stanford Coccid collection second in importance in the Uuited States only to the National Collection at Washington. The types of all of the species that have been described (approximately 100) from this laboratory, are deposited here.

The work of publishing the results of the studies on the collection is being, and will continue to be, pushed as rapidly as possible.

R. W. Doane

An Unusual Type of Injury to Sweet Potatoes in Texas by a Burrowing Bee. July 28, 1920, the writer received word from a farmer in Ricardo, Tex., that a new insect, which resembled a bee, was injuring sweet potatoes and that the pest was present by the thousands or millions. As the grower had not been able to irrigate, the plants were gradually drying up. The writer, upon investigation, found the field alive with bees, swarming in the air and on the ground. Many were just emerging from the soil while others appeared to be "digging in." The ground in spots was honeycombed with burrows made by the emerging bees, identified by Mr. S.

A. Rohwer as *Nomia nortoni* Cress. Emergence was at first localized, but in a few days the bees appeared in all parts of the fields, although more numerous in some places than others. Maximum abundance continued for about a week, after which their number gradually decreased. All were gone in about 15 days, disappearing as suddenly as they had appeared. The report of the grower as to the condition of the sweet potato crop was found to be correct. The plants were somewhat shriveled and plainly showed the lack of moisture. On the side of the field first attacked by the bees they had assumed a yellowish appearance. Some were almost uprooted by the bees in their mining.

Nomia nortoni is slightly larger and darker than the honey bee. Unlike many mining bees, it does not construct common burrows with branches terminating in a single cell. These tunnels more often than not terminate in a single nest which consists of from 4 to 12 cells, the majority examined containing 6 to 8 cells. Most of the burrows ran perpendicularly into the ground for from 8 to 48 inches, usually ranging from 18 to 24 inches in depth. Only two burrows were found as deep as 48 inches. Three instances were observed where the same tunnel from the surface appeared to have been used as a passage from two nests, the second nest being about 8 inches directly below the first. The writer cannot be positive as to this, however, as the nature of the soil and the close proximity of the burrows rendered difficult the tracing of any single tunnel all the way down to the nest. At the bottom of the burrow, the nest proper was held in a pocket-like cavity, the walls of which were at such distance from the brood cells as to render each readily accessible. It was constructed of moistened and kneaded earth, irregular in outline and about the size of a lemon. The walls of each cell in the nest had been tightly sealed and glazed. A few dead bees were found in the cells, although the majority were empty.

The writer has been unable to find the new home of these bees, but it is evident that they did not deposit all over this plot, for no trace of bees was found in the several holes that were dug. No doubt with the aid of a steam shovel the bees could be located in a short time to ascertain the stage present at this time. The nests appeared to have been tightly sealed before the bees emerged and their construction showed that the builders possessed some ingenuity. The writer hopes that he may be able to secure more data on this insect at a later date. The bees caused the sweet potato crop in this locality to be a total failure. The plot could not practically be irrigated from the small well after the bees had finished with their tunneling of the soil, as the plat was a sandy loam soil underlaid with a stratum of "caliche" (limestone) that would take up the water faster than it could be applied. The bees did no other injury to the sweet potatoes than filling the soil full of burrows, which prevented irrigation and later caused the plants to dry up.

The pest was injurious to sweet potatoes in this locality in 1915, but at that time the writer was able to secure only a single specimen, as the bees had practically disappeared when he arrived on the ground. It appears that the bee prefers to deposit in soil that has been irrigated since no report has been received of it doing damage to non-irrigated soil.

M. M. HIGH

Entomological Assistant, Truck Crop Insect Investigations, United States Department of Agriculture

Subcortical Temperatures of Logs Exposed to Direct Sunlight. During the past year the attention of entomologists has been called to the fact that the temperature

beneath the bark of logs lying in full sunlight may reach a degree fatal to insects.[1] Craighead working with ash logs in several localities in the South observed subcortical temperatures which exceeded air temperature by 60° (F?) depending upon the locality, condition of the sky and angle of the sun's rays. On the basis of his experiments he recommends the weekly turning of logs to protect them from wood destroying insects.

So far as some species of logs are concerned, the author has independently reached similar conclusions from work conducted at the Minnesota Experiment Station. But these experiments have also shown that, in northern latitudes at least, some logs never reach the fatal temperature for insects even on the brightest days. Thus it is essential that the factors influencing the subcortical temperature should be understood if this method of control is to be used intelligently. A more complete discussion of the factors influencing the subcortical temperature of logs will appear in the 18th Report of the Minnesota State Entomologist.

The results thus far obtained may be summarized as follows:

1. In bright sunlight subcortical temperature on the upper side of moderately thin barked logs often passes above a point fatal to insects.

2. That this is not true of all logs is illustrated by certain thin barked Norway pine logs, the subcortical temperature of which never exceeded 46°C during the entire summer season of 1920.

3. One of the primary factors influencing the temperature in logs is solar radiation. The effect depends upon light intensity, solar altitude and the angle of incidence of the sun's rays upon the log.

4. The position of the log with reference to the sun's rays determines the proportion of the log which may attain a high temperature. Logs lying east and west will have heated only a comparatively narrow strip on the south side while almost one-half of the log lying north and south may exceed the fatal temperature of insects.

5. The bark characteristics which affect log temperatures are: (a) Color. Dark bark absorbes heat much more rapidly than light colored bark. (b) Surface. Rough bark provides a larger absorbing and radiating surface than smooth bark and gives higher temperatures, provided the angle of incidence is not great. (c) Structure. Scaly bark is a better non-conductor than bark of a uniform dense structure and therefore tends to hold down temperature. (d) Thickness. This tends to increase insulation.

6. In absence of solar radiation the subcortical temperature follows rather closely the temperature of the surrounding air.

7. The conduction of heat around a log is slow, but varies somewhat with the different species. This results in the concentration of heat in limited areas.

8. Air movement tends to increase radiation and therefore tends to reduce subcortical temperatures.

9. Evaporation of water from the surface layers of the bark, which often occurs in the early morning or following rain tends to reduce the temperature beneath the bark.

10. Close proximity to other radiating or absorbing surfaces tends to stabilize subcortical temperature.

[1]F. C. Craighead (1920) Direct Sunlight as a Factor in Forest Insect Control. Proc. Ent. Soc. of Wash., Vol. 22, pp. 106-108.

S. A. Graham

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

JUNE, 1921

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published as far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceeding publication. Contributors are requested to supply electrotypes for the larger illustrations as far as possible. Photo-engravings may be obtained by authors at cost. The receipt of all papers will be acknowledged.—EDS.

Separates or reprints, if ordered, when the manuscript is forwarded or the proof returned, will be supplied authors at the following rates:

Number of pages	4	8	12	16	24	32
Price per hundred, or less	$3.75	$8.00	$9.35	$10.30	$15.15	$20.00
Additional hundreds, or less	.55	1.15	1.75	1.75	2.75	3.75

Covers suitably printed on first page only, 100 copies, or less, $4.65; additional hundreds, or less $1.40. Plates inserted, $1.25 per hundred, or less. Folio reprints, the uncut folded pages (50 only), sixteen page signature, or less, $1.85. Note that the number of pages in a reprint may be affected somewhat by the make-up. Carriage charges extra in all cases. Shipment by parcel post, express or freight as directed.

It is perhaps unnecessary to state that the appearance of this issue has been greatly delayed by the printers' strike. The August number is now in press and may be mailed shortly.

The Insect Pest Survey recommended by the association at its last meeting is an accomplished fact and the first two issues of the monthly Bulletin and a number of special Reports give a more definite idea of possibilities than could be obtained from any general discussion of plans. The survey organization affords a ready means of picturing the seasonal developments of the country and as a whole it will be of value in proportion to the cooperation it receives.

It has started excellently and it remains for those who advocated the departure to give such support that there can be no question as to the merits of the undertaking. Insect life recognizes no political boundaries and is very subject to local and more or less irregular, frequently poorly understood fluctuations. One problem of the survey is to accumulate all such data and as general tendencies become better known, the probabilities of utilizing them in practical ways are greatly increased. The survey may be characterized as a nation-wide attempt to cooperate along scientific lines. It can succeed only through mutual service. The men in the field must provide data,—there can hardly be too much. Those in charge must see that the information is promptly distributed in a convenient form. As a consequence of organizing this survey, every man's work will have a perspective not heretofore possible in many instances. There are also great possibilities in the proposed annual digest and later, as data accumulate, in the recognition of distinct tendencies in various sections. The successful control of insect

life depends upon exact knowledge of the behavior of insects. There have been in recent years many close studies of individual insects or groups of insects for the purpose of obtaining such data. The Insect Pest Survey has opened up a line of investigation capable of rendering great, possibly greater service than the study of restricted problems, though both are essential to material advances along progressive lines.

Reviews

Report of the Proceedings of the Third Entomological Meeting held at **Pusa, 3rd to 15th February, 1919,** edited by T. BAINBRIGGE FLETCHER, 3 vols. pages 1-1137, 182 plates (many colored), Calcutta, Superintendent Government Printing, India, 1920

This set of volumes is a magnificent contribution to our knowledge of Indian insects and reflects great credit upon all participating in the conference. Nearly three hundred (300) pages are devoted to an annotated list of Indian crop pests and such unusual subjects, from the American view point, as methods of storing grain, Lantana insects and Lac production receive attention in addition to the numerous notes concerning a very large number of insects, a few of which are known as pests in this country, though most represent an entirely different fauna.

These volumes are a mine of information and though dealing with insects of a totally different section of the world, contain much of interest to American Entomologists.

E. P. F.

Insect Pests of Farm, Garden and Orchard by E. DWIGHT SANDERSON, revised by L. M. PEAIRS, pages I-VI, 1-707, 604 text illustrations, John Wiley & Sons, Inc., New York, 1921.

This is a revised and enlarged edition of the senior author's well known work published under the same title in 1912. The revision has been directed mainly toward bringing control measures up to date, though there have been modifications of the text and important additions, particularly the chapters in relation to insects injurious to citrus fruits, to man and in the household and to domestic animals and poultry. The chapter on insects affecting hops of the first edition has been eliminated and the account of the hop plant louse as a plum pest considerably reduced and the discussions of other hop insects discarded, presumably because of their relatively slight importance so far as the country as a whole is concerned. Can this be an indirect outcome of the Volstead Act? The authors have rendered a distinct service by reproducing in permanent form a number of the diagrammatic illustrations of the life history and activities of important insects issued during recent years by the Federal Bureau of Entomology, though the reductions of certain posters have of necessity been somewhat greater than was desirable

The authors gave nothing as to the value of corrosive sublimate for the control of cabbage maggot and the efficacy of timely sprayings with ordinary arsenicals

for checking the apple maggot. Both of these are somewhat recent developments and may not have become sufficiently established before the forms for these particular chapters were closed. The volume bears the date of 1921 and although the preface is dated May 1920, it would have been desirable, in the opinion of the reviewer, to have included a brief statement of the noteworthy extensions of infested territory by both European Corn Borer and Gipsy Moth known by mid-summer 1920. A study of a general infestation by wheat midge leads the reviewer to place little dependence on the remedial measures outlined for this insect, tho these are based upon well accepted literature of the past and at the present time nothing very definite can be advised.

The earlier edition was a most excellent and exceedingly helpful digest of the then known entomological facts. This revision with its greatly increased number of illustrations, is destined to be the most convenient and reliable, general work for some years to come. It will be exceedingly serviceable to both Entomologists and Agriculturists and should be available to all interested in the control of the numerous insects affecting the varied crops of America.

E. P. F.

Current Notes

Mr. A. F. Burgess addressed the meeting of Local Moth Superintendents at Boston, March 23.

The semi-annual meeting of the Nova Scotia Entomological Society was held in Halifax, February 9.

Miss Evelyn Osborn is now professor of entomology in the Agricultural College, Syracuse University, Syracuse, N. Y.

Mr. W. S. Blatchley of Indianapolis, Ind., spent the winter at his winter home in Dunedin, Fla.

The twelfth annual meeting of the British Columbia Entomological Society was held in Vancouver, on February 12.

According to *Science*, Dr. Walter E. Collinge, of St. Andrews University, has been appointed keeper of the York Museum.

Mr. H. L. Seamans has been appointed provincial entomologist for Alberta, B. C., and reported at Lethbridge, March 30.

Sixty students are now enrolled in the course in beekeeping given to the vocational students in agriculture by Mr. Frank S. Stirling at the University of Florida.

Mr. U. C. Loftin has resigned from the Bureau of Entomology to accept a position as entomologist with a cotton company operating in the Laguna district of Mexico.

Mr. E. H. Strickland of the Canadian Entomological Branch, left Ottawa on February 14, for Alberta, to join the Inter-provincial Weed Train, to give lectures on grasshoppers and cutworms, returning on March 12. During this period he gave 49 lectures to some 4500 people.

According to *Gleanings in Bee Cultura*, the State of Pennsylvania has just enacted a new foul brood law, making it unlawful to ship bees, hives, or appliances into the State, unless accompanied by a certificate of inspection from State or county from where they are shipped.

A bill is now before the Rhode Island Legislature asking for an appropriation of $20,000.00 for the purpose of eradicating mosquitoes in such towns and cities as may appropriate funds for such work.

Mr. T. J. Tothill of the Canadian Entomological Branch, visited Washington, D. C., in March to engage in systematic work at the U. S. National Museum, taking along some Canadian material for comparison.

According to *Science*, Professor George C. Embody has returned to Cornell University, after spending the period since last September establishing at the University of Washington the first college of fisheries in an American University.

Dr. T. J. Headlee appeared by request before the legislative committee on Public Health and Safety at Hartford, Conn., February 16, to explain the progress and value of anti-mosquito work in New Jersey.

According to *Science*, the death is announced of Professor Louis Compton Miall, F. R. S., formerly professor of biology at the University of Leeds, and author of *Natural History of Aquatic Insects*, at the age of 79 years.

Mr. Loren B. Smith severed his connection with the Virginia Truck Experiment Station at Norfolk, April 1, to accept a position as agent of the U. S. Bureau of Entomology, in charge of biological studies, Japanese Beetle Investigations, at Riverton, N. J.

According to *Science*, Professor Herbert Osborn, of the Ohio State University, has recently returned from a two months' trip to Florida, during which he collected insects at different points in the state in co-operation with the State Plant Board of Florida.

Mr. L. S. McLaine of the Entomological Branch, Ottawa, Canada, attended the meeting of the local Moth Superintendents, and the Massachusetts Tree Wardens' and Foresters' Association, at the Boston City Club, Boston, Mass., March 23. He also visited the corn borer laboratory at Arlington.

Mr. J. E. Graf is now in charge of the field work in the organization which the Bureau of Entomology has established for preventing the spread of the Mexican bean beetle in Alabama. Mr. Neale F. Howard will be in charge of the research work.

Mr. Arthur Gibson, Dominion Entomologist, has recently been appointed a member of the Lyman Entomological Bequest Committee and attended a meeting of the Committee, held at McGill University, Montreal, on February 16.

A Smoker was held by the Florida Entomological Society on January 17th, in honor of Professor Herbert Osborn, who spent a portion of the winter in Florida. Upwards of forty members and invited guests were present, and an enjoyable evening will be remembered by all. Dean Wilmon Newell acted as toastmaster.

Messrs. W. R. Walton, L. H. Worthley and D. J. Caffrey of the Bureau of Entomology visited the European corn borer infestation in western New York on March 21. The corn stalks and stubble have been removed and burned or crushed over an area of nearly 1000 acres in this region.

Dr. E. F. Phillips of the Bureau of Entomology attended a meeting of the Maryland State Beekeepers' Association at Baltimore, March 18, the annual meeting of the West Virginia Beekeepers' Association at Charleston, March 25-26, and a special meeting of the beekeepers' during Farmers' Week at the University of Maine, Orono, on March 30.

At the annual meeting of the Florida Entomological Society held at Gainesville, Jan. 24, the following officers were elected for the year: President, Professor J. R. Watson: Vice-President, P. W. Fattig; Secretary, Jeff Chaffin; Treasurer, Dr. E. W. Berger; Member of Executive Committee, O. F. Burger, Professor Herbert Osborn was elected an honorary member of the Society.

The following transfers have been made recently in the Bureau of Entomology: K. B. McKinney, George H. Bradley, M. T. Young, R. C. Gaines and W. R. Smith have returned to the Bureau from temporary employment by the Federal Horticultural Board; John B. Gill, Brownwood, Texas, temporarily to Fort Valley, Ga.; C. N. Ainslie, Knoxville, Tenn., to Sioux City, Ia.

According to *Entomological News*, Mr. Edward P. Van Duzee, Curator of Entomology at the California Academy of Sciences, left San Francisco, March 30, for Guaymas, Mexico, where he will join an expedition organized by the Academy for the scientific exploration of Lower California and the adjacent islands. He goes as entomologist of the expedition and expects to return to San Francisco in August.

The principal activities in the corn borer investigations in New York State wil be transferred to Silver Creek, at an early date with Mr. H. N. Bartley in charge for the present. Mr. J. H. Harmon has been placed in charge of the operations near Schenectady and will maintain a small force at that point for the purpose of studying the insect in that vicinity.

The following resignations from the Bureau of Entomology have been reported: C. F. Turner, formerly in charge of corn borer investigations, Schenectady, N. Y., to engage in commercial fruit growing at Memphis, Tenn; G. H. Cale, apiculture, to take charge of the Dadant Apiaries at Hamilton, Ill.; L. G. Gentner, truck crop insect investigations, to become an instructor in entomology, Michigan Agricultural College; F. L. O'Rourke, corn borer work, Arlington, Mass.

Dr. W. E. Britton addressed the tenth annual meeting of the Massachusetts Tree Wardens' and Foresters' Association at Boston, March 23, on "Registration of Shade Tree Workers, and Shade Tree Insect Troubles."

Mr. Stephan Keler, Forest Entomologist, Lemberg (Lwow) Tarnowskiego 45, Poland, would like to communicate with American entomologists interested in the Coleoptera of Poland. His specialty is the bark beetles (Ipidae) and he would like to obtain specimens from the United States in exchange for Polish ones. He has also material in other families of Coleoptera, which he will exchange for American (U. S.) literature of Ipidae, s. str., and of forest entomology, s. lat.

Enos B. Engle, chief nursery inspector and oldest member both in years and term of service, of the Bureau of Plant Industry of the Pennsylvania Department of Agriculture, celebrated his eightieth birthday anniversary recently. He is a veteran of the Civil War, remarkably vigorous in both mind and body and has made a record worthy of emulation by youngsters of seventy-five or less.

Entomological News records the death on October 25, 1920, at Florence, Italy, of Dr. Odoardo Beccari, and of Professor Tsunekata Maiyake, of the Agricultural College of the Imperial University of Tokio, Japan, in February 1921. Dr. Beccari was director of the Botanical Garden, but from 1865-1876 he explored Indo-Malaysia and Papua and collected many insects; he has published an account of the formicary plants of Malaysia and Papuasia. Professor Maiyake is the author of a general treatise on entomology and of many special papers on the biology of insects, including several economic species.

Mr. J. A. Hyslop of the Bureau of Entomology has been placed in charge of the new Insect Pest Survey which is being conducted by the Bureau of Entomology in response to resolutions adopted at the Chicago meeting of the American Association of Economic Entomologists. As the Bureau has no appropriation for this work, the data must be collected largely from the State entomological agencies, and 48 entomologists have accepted their appointment as insect pest reporters for this work. A summary of these reports will be issued each month. The first regular bulletin appeared May 1, and several special bulletins have been issued.

Recent appointments to the Bureau of Entomology have been announced as follows:- Herbert D. Smith, Massachusetts Agricultural College, Scientific Assistant, Hessian Fly work, Carlisle, Pa.; E. L. Sechrist, bee culture investigations, Washington; R. W. Kelley, formerly of the Bureau and later in charge of the Insecticide and Fungicide Laboratory at Vienna, Va., fruit insect investigations on Japanese beetle work, Riverton, N. J.; Luther Brown, quarantine and regulatory work, Mexican bean beetle; L. L. English, field experiments, Mexican bean beetle; Dr. W. E. Hinds, Alabama Experiment Station, Collaborator, Mexican bean beetle; W. J. Nolan, Apicultural Assistant; Wallace E. Haley, sugar cane insect laboratory, New Orleans, La.; Theodore Henry Frison, University of Illinois, Japanese beetle project, Riverton, N. J.; C. E. Johnson, apple insect investigations, Bentonville, Ark.; C. H. Brannon, Mississippi Agricultural College, plum curculio control, Fort Valley, Ga.; Stewart Lockwood, specialist in Orthoptera for Federal work in controlling grasshoppers in the northwestern states, Fargo, N. D.

Transfers U. S. Bureau of Entomology; W. R. Smith and R. C. Gaines, Federal Horticultural Board to boll weevil force, Tallulah, La.

Mr. H. H. Thomas has been appointed temporary junior assistant, Division of Forest Insects, Entomologicial Branch, Canadian Department of Agriculture.

Mr. C. O. Eddy, a graduate of the Ohio State University, has been appointed instructor in Zoology and Entomology, North Carolina State College.

Mr. Eric Hearle of the Entomological Branch, Canadian Department of Agriculture, who is engaged in mosquito work, was married, April 9, to Miss I. B. Webb, of Hatzic, B. C.

Dr. Philip Garman of the Connecticut Agricultural Experiment Station was operated upon for appendicitis at Grace Hospital, New Haven, Conn., on May 15. At last accounts he was getting along nicely.

Mr. J. E. Eckert, Ohio State University 1916 and 1917, has been appointed Assistant Professor of Zoology and Entomology, North Carolina State College and will devote most of his time to apiculture.

Dr. W. D. Hunter and Mr. B. R. Coad of the Bureau of Entomology spent the greater part of April in the Laguna district of Mexico, in connection with the pink bollworm problem.

Prof. Z. P. Metcalf of the North Carolina State College and Experiment Station will have charge of the courses in elementary and advanced entomology at the University of Michigan Biological Laboratory, Douglas Lake, this summer.

Dr. A. W. Morrill, Consulting Entomologist, of Los Angeles, Calif., spent a month on the west coast of Mexico during the past spring investigating pests of cotton and miscellaneous crops for several of his clients. He is now planning to locate an assistant in Sinaloa under contract for continuing certain investigations and for acting in an advisory capacity to American and Mexican land owning corporations and growers organizations.

Dr. H. B. Hungerford of the University of Kansas will spend the summer at the University of Minnesota where he will be a member of the Entomological staff. He will give a summer school course in Economic Entomology and will continue his studies upon Aquatic Hemiptera.

Dr. W. E. Hinds of Alabama was elected Chairman, and Professor A. F. Conradi, of South Carolina, Secretary, of the Association of Cotton States Entomologists, at the 22nd annual Convention of Southern Agricultural Workers, held at Lexington, Ky., February 15-17, 1921.

Dr. J. F. Illingworth, who, for the past four years, has been under engagement with the Queensland Government, investigating pests of sugar cane, is returning with his family to their home in Hawaii. For the present his address will be University of Hawaii, Honolulu, T. H.

According to *Gleanings in Bee Culture* the course in bee keeping at the Massachusetts Agricultural College, which was suspended several years ago on the resignation of Dr. Burton N. Gates, is to be reinstated under Mr. Norman E. Phillips a brother of Dr. E. F. Phillips of the U. S. Bureau of Entomology.

Mr. Dwight Isely, Scientific Assistant in the United States Bureau of Entomology, has resigned and has accepted the position of Associate Professor in the Department of Entomology, University of Arkansas, and Associate Entomologist in the Experiment Station. He will devote most of his time to research work.

Dr. C. L. Metcalf, for the past seven years Professor of Entomology in Ohio State University, has resigned to accept the position of Professor of Entomology and Head of the Department of Entomology in the University of Illinois. He should be addressed in care of the University at Urbana, Illinois, after September first.

According to *Science*, Doctor Vernon Kellogg, Secretary of the National Research Council, gave three lectures on January 10, 17 and 24, on "Human Life as the Biologist Sees It" at Brown University, on the Charles K. Colver Foundation. These lectures will be published in book form by Houghton, Mifflin Company.

The Louisiana Entomological Society begins its second year with thirty-three members, including persons connected with the Louisiana State Museum, Louisiana Experiment Stations, Tulane University, Louisiana State University, U. S. Bureau of Entomology, Federal Horticultural Board, besides private collectors, beekeepers and others. Outside of Louisiana there are members in the District of Columbia, Mississippi, Kansas, Texas, and Mexico. At the February meeting, which was held at Baton Rouge, twenty-one were in attendance. The following papers were read: "Work on Malarial Mosquitoes at Mound Laboratory, Mound, La.", by D. L. Van Dine of the Bureau of Entomology; "Beekeeping in Louisiana," by E. C. Davis, of the Louisiana Experiment Stations; "Present Status of Cattle Tick Control in Louisiana," by W. H. Dalrymple, Director of the Louisiana Experiment Stations. The plan has been adopted of following the regular meeting with a "carry over" meeting to be held the day following, at which more technical matters will be discussed, the program for the next meeting will be arranged, etc.

The annual State meeting of Entomological Workers in Ohio Institutions was held at Columbus February 3, J. S. Houser, president, H. J. Speaker, vice-president and T. H. Parks, secretary.

The following papers were read:

P. R. Lowry—Economic Importance of Mealy Bugs in Ohio.

C. H. Kennedy—Notes on Dragon Flies.

E. A. Hartley—Remarks on some Aphid Parasites.

E. C. Cotton—Recent Developments of Gypsy Moth and European Corn-borer Liable to be Introduced.

W. O. Hollister—The Tree Surgeon's Knowledge of Entomology.

L. L. Huber—Remarks on a Chalcidoid Parasite.

W. V. Balduf—Life History and Habits of the Cucumber Beetle.

J. S. Houser—Control of the Cucumber Beetle.

W. M. Barrows—Insect Orientation to Heat Rays.

E. L. Chambers—Greenhouse Insect Control on a Commercial Scale.

R. C. Osburn—Next Steps in Entomological Study.

W. C. Kraatz—Notes on Aquatic Insects in Ohio.

C. L. Metcalf—The Elementary Course in Economic Entomology.

F. H. McMillen—How Entomology is Taught by the Smith-Hughes Teacher.

Ford S. Prince—Entomology's Place in County Agent Work.

H. E. Evans—The Farmer and Taxpayer's Opinion of the Application of Entomological Control Methods.

H. A. Gossard—Devices for recording the Emergence of Hessian Fly Broods.

T. H. Parks—Some Remarks on Hessian Fly and its Control.

E. W. Mendenhall—Some of the Insect Pests Found in Northeastern Ohio.

W. S. Hough—Methods Employed to Control and Eradicate the Pink Boll Worm.

E. L. Wickliff—Insect Food of Certain Ohio Fishes.

J. S. Hine—Blood-sucking Insects Observed on the Katmai Expedition.

The newly elected officers are: President, C. L. Metcalf; Vice-President, E. W. Mendenhall and Secretary, T. H. Parks.